UC Berkeley
Agricultural and Resource Economics Update

Title
ARE Update Volume11, No.3

Permalink
https://escholarship.org/uc/item/64f644q1

Authors
Kahrl, Fredrich
Roland-Holst, David
Rajagopal, Deepak
et al.

Publication Date
2008-02-01

eScholarship.org Powered by the California Digital Library
University of California

Agricultural and Resource Economics
UPDATE
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS • UNIVERSITY OF CALIFORNIA
V. 11 no. 3 • Jan/Feb 2008

What Hope for Climate Multilateralism?

Fritz Kahrl and David Roland-Holst

It is increasingly clear that significant global warming cannot be averted without a multilateral initiative to reduce greenhouse gas emissions. Unfortunately, global consensus is deadlocked between high-income countries, responsible for the majority of the stock of emissions, and low-income countries whose industrialization contributes significantly to current and expected future greenhouse gas flows. Because of the intrinsic linkage between carbon technologies and living standards, an underlying equity problem confounds the prospects for reconciling North and South.

Also in this issue

Faculty Profile: David Roland-Holst 4

The Use of Environmental Life-Cycle Analysis for Evaluating Biofuels
Deepak Rajagopal and David Zilberman 5

Enhancing Producer Returns: United Potato Growers of America
Shermain D. Hardesty.....9

In the next issue.....

Special Report on the California Wine Industry

Global warming results from ambient concentrations of greenhouse gases (GHG) in the Earth's atmosphere. These concentrations have increased significantly since the Industrial Revolution, when carbon technologies were leveraged to achieve unprecedented improvements in living standards. Roughly three-quarters of the GHG stock change since 1750 was produced by OECD economies (OECD is an international organization of 30 industrialized countries). However, newly emergent economies are now important contributors. China, for example, became the largest single GHG emission source in 2007. While a majority of high-income countries have begun substantive multilateral climate action, emerging economies appear reluctant to be drawn into such agreements. Without their cooperation, however, it is unlikely that GHG concentrations can be stabilized.

At a fundamental level, the causes and effects of climate change represent an equity problem involving two global stakeholder groups:

Carbon Legacy Economies (CLE): Those countries responsible (mainly OECD) for the majority of atmospheric greenhouse gas stocks, who will continue to represent a significant share of future greenhouse gas flows, sometimes referred to as 'developed countries';

Carbon Emergent Economies (CEE): Those countries (e.g., China and India) who will be responsible for the majority of growth in greenhouse gas flows and an increasing share of future atmospheric greenhouse gas stocks, including those referred to as 'developing countries.'

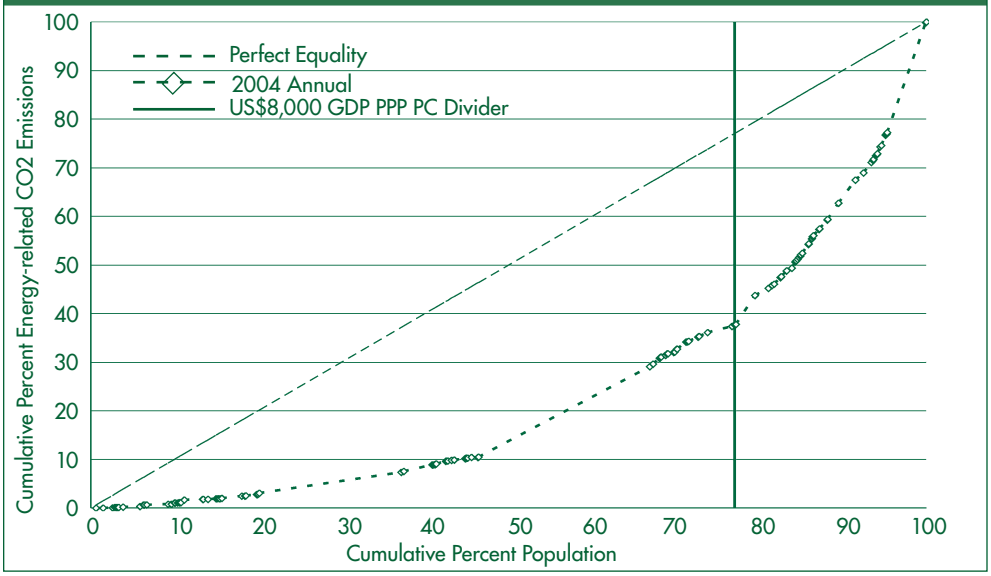
Despite mounting concern over rapid greenhouse gas emission growth in CEE countries, in this paper we argue that emissions growth will not fundamentally alter the carbon equity balance between CLE and CEE countries. Climate change is, and will continue to be, a problem caused predominantly by wealthy countries.

A useful device to visualize CLE-CEE carbon inequality is the Lorenz curve, a device used in economics to illustrate income distribution and other equity variables. In the present context, "CO2 emissions" or carbon Lorenz curves show the distribution of energy-related CO2 stocks and flows among countries on an implied per capita basis, with the cumulative percent of energy-related CO2 emissions on the y-axis and the cumulative percent of population on the x-axis, ranked by per capita income. All the Lorenz curves in this exposition use GDP per capita at purchasing power parity (PPP) to rank population along the x-axis.

Because of their per capita roots, Lorenz curves provide an important tool for considering equity in global climate negotiations. This paper elucidates the perspective of per capita emissions and incidence as logical and ethical bases for global climate policy dialogue between North and South.

Figure 1 provides an example of a CO2 emissions Lorenz curve for 2004. The 45 degree line represents the line of

Figure 1: Global Composition of Population and Energy-Related CO2 Emissions



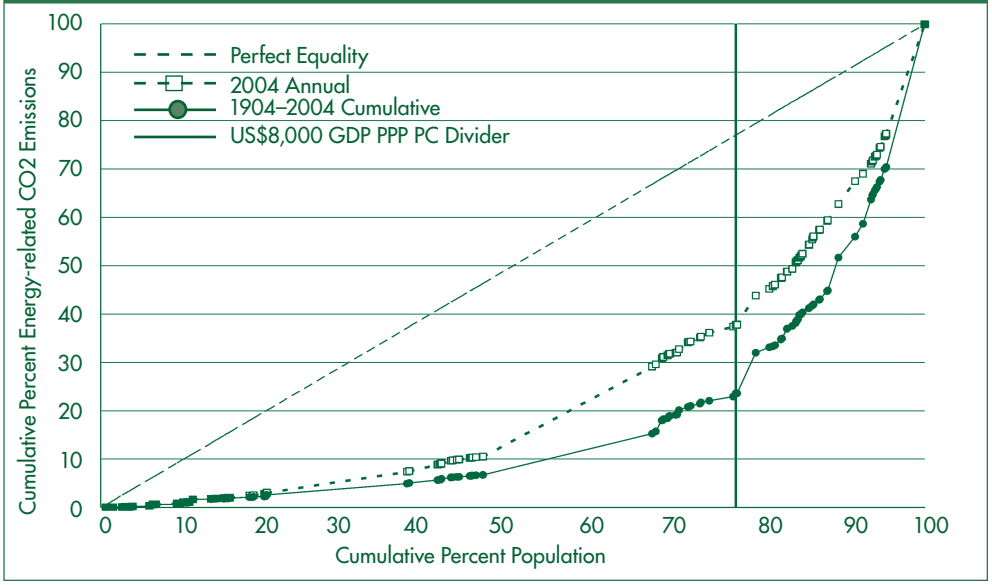
perfect equality, where national CO2 emissions are equalized globally on a per capita basis. The area between the line of perfect equality and the actual distribution (Lorenz) curve is termed the ***Gini coefficient of inequality***, calculated using emissions levels in place of incomes.

A Gini coefficient of zero corresponds to perfect equality, while a theoretical Gini coefficient of one would indicate all emissions arise from one person.

The Gini coefficient in Figure 1 is 0.52. To put this in context, Brazil, a country with relatively high income inequality, had an income Gini coefficient of 0.54 in 2004. Another way to interpret Figure 1 is that the 77 percent of the world's population with per capita GDP PPP of less than US$8,000, accounted for 38 percent of global energy-related CO2 emissions in 2004, while the 23 percent with GDP per capita (corrected for Purchasing Power Parity) over US$8,000 accounted for 62 percent of global energy-related CO2 emissions. As a dividing line between lower and higher income countries, US$8,000 separates Romania and Costa Rica.

We use Lorenz curves to demonstrate two facts about global CO2 emissions—past, present, and future. First, from either a flow or stock perspective, carbon inequality is currently at levels that are unlikely to sustain multilateral cooperation in the absence of transfer mechanisms. Second, even with significant emissions growth in CEE countries over the next two decades, the fundamental imbalance in carbon stocks between CLE and CEE countries will not disappear.

Figure 2: Current (2004 flow) and Cumulative (1904-2004 stock) CO2 Emissions



2004 CO2 Emissions and 1904–2004 Cumulative CO2 Emissions

Figure 2 shows the distribution of 2004 energy-related CO2 emissions (flows) and cumulative 1904–2004 energy-related CO2 emissions (stocks). By using a 100-year time frame for the latter, we implicitly assume a 100-year residence time for CO2 in the atmosphere. Extending emissions back this far in time likely overestimates the share of industrialized countries' emissions, given that better data on primary energy use exist in these countries. Similarly, we do not include emissions from land-use change in our Lorenz curves, which also biases them toward higher shares of emissions from industrialized countries. Nonetheless, given that climate change is driven in significant measure by the combustion of fossil fuels, Figures 2 and 3 provide a revealing perspective on the political economy of greenhouse gas emissions.

As noted previously, the 2004 annual curve has a Gini coefficient of 0.52. Note now that 1904–2004 stocks are significantly more unequal than 2004 flows, i.e., the 1904–2004 Cumulative curve has a Gini coefficient of 0.64, placing it on par with the world's most income-unequal societies. Put differently, the 77 percent of the world's population to the left of our US$8,000 dividing line contributed less than 24 percent to the world's atmospheric stock of fossil fuel CO2 emissions from 1904–2004, while 23 percent of the world's population to the right contributed more than 76 percent.

If conventional wisdom on the relationship between energy demand and economic growth is to prevail in the near

term, convergence of incomes between developing and developed countries will require significant growth in per capita energy consumption and, without changes in the world's dominant reliance on fossil fuels, significant growth of per capita CO2 emissions in developing countries.

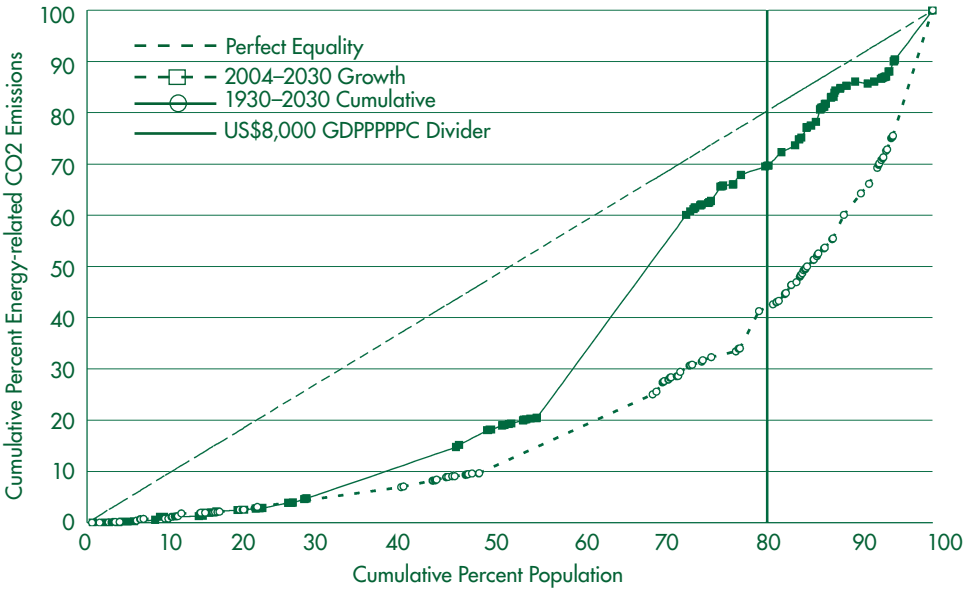
2004–2030 CO2 Emissions Growth and 1930–2030 Cumulative CO2 Emissions

Figure 3 shows the distribution of projected 2030 energy-related CO2 emissions and implied cumulative 1930–2030 energy-related CO2 emissions, using the International Energy Agency's reference scenario projections and updating cumulative emissions data to 2030. These projections are only available at an aggregate, regional level. To disaggregate regional totals by country, we assume that the national shares of 2004 regional emissions are the same as those in 2030. To calculate 2030 cumulative emissions, we assume an average, annualized growth rate in energy-related CO2 emissions from 2004–2030. For the x-axis in Figure 3, we use 2030 population projections from the United Nations, but rank these by 2004 GDP PPP per capita.

As Figure 3 illustrates, 80 percent of the world's population to the left of the US$8,000 divider accounts for nearly 70 percent of the growth in annual energy-related CO2 emissions from 2004–2030. Because much of this emissions growth occurs in the world's most populous countries—China (the nearly vertical line dominating the middle of the figure) alone is projected to account for almost 40 percent of growth in annual energy-related CO2 emissions from 2004–2030 — the Gini coefficient on the 2004–2030 Growth curve is 0.33, comparable to income inequality in northern European countries.

Despite their sizeable contribution to the growth of CO2 emission flows, rapid industrialization in developing countries will not significantly alter the balance in global carbon inequalities over the next two decades. The CO2 stock share of the world's upper-income quintile (countries representing the 20 percent of the world's population to the right of the US$8,000 divider) falls from roughly 76 over 1904–2004 to 66 percent over 1930–2030. Because of its shrinking share of global population and the persistence of atmospheric carbon stocks, the 1930–2030 Cumulative curve Gini coefficient falls by only four percentage points (0.60) vis-à-vis the 1904–2004 Cumulative curve coefficient (0.64). In other words, rapid growth in fossil fuel CO2 emissions in CEE countries will not alter the fundamental imbalances in carbon stocks that divide CLE and CEE countries.

Figure 3: Past and Future Cumulative Emissions



Conclusion

International economic disparities are widely perceived as an obstacle to international conventions to reduce greenhouse gas emissions. Carbon Legacy Economies frequently exhort Carbon Emergent Economies to be more aggressive on climate action, while the latter defer on the grounds of growth opportunity cost. This paper presents new evidence regarding the equity problem that underlies this debate. When viewed on a per capita basis, global GHG emissions are distributed very unequally, a fact that undermines the moral authority of high-income economies to advocate mitigation in low-income countries without some transfer or other incentive mechanism. A second important finding is how limited is the capacity of Carbon Emergent Economies to alter the GHG stock imbalances represented by legacy emissions that are largely due to the high-income economies. This conjunction of environmental and economic evidence has profound implications for global climate negotiations.

David Roland-Holst is an adjunct professor in the Department of Agricultural and Resource Economics and Fredrich Kahrl is a Ph.D. student in the Energy and Resources Group, both at UC Berkeley. They can be reached by e-mail at dwrh@are.berkeley.edu and fkahrl@berkeley.edu, respectively.

Sources for Figures 1–3: Population, GDP PPP, and 2004 energy-related CO2 emissions data are from the International Energy Agency and World Resources Institute.

For Further Reading

Agarwal, A. and Narain, S., 1991, Global Warming in an Unequal World: A Case of Environmental Colonialism. Center for Science and Environment, New Dehli.

International Energy Agency (IEA), 2006b, World Energy Outlook. IEA, Paris.

Faculty Profile: David Roland-Holst

David Roland-Holst
Adjunct Professor
Department of Agricultural and Resource Economics
UC Berkeley

David Roland-Holst joined the faculty of the agricultural and resource economics department at UC Berkeley as an adjunct professor in August 2004. He holds a Ph.D. in economics from UCB, where his original fields were development and mathematical economics. Prior to joining ARE, David taught at Mills College where he maintains his position as a Professor of Economics. One of the world's leading experts on policy modeling, he has extensive research experience in economics related to environment, development, agriculture, and international trade, authoring three books and over 100 articles in professional journals and books. David has served in academic posts in Asia, Europe, and the United States. He has conducted research in over 40 countries, working with many public institutions including a variety of federal and state agencies, the Asian Development Bank, Inter-American Development bank, Organization for Economic Cooperation and Development (OECD), World Bank, several United Nations agencies, and governments in Asia, Latin America, Europe, and the United States.

David's current research spans a diverse set of topics including climate policy, biofuel, China's development, infrastructure/development linkages, and avian influenza.

His empirical work made an important contribution to the legislative process leading up to California's path-breaking Global Warming Solutions Act. Results of his analysis were quoted in the Governor's executive order establishing the Act, and he has since produced a series of reports on the state's prospects for transition to a regime of market-based greenhouse gas targeting. As a member of the Energy Biosciences Initiative, David is leading research into the influence of biofuel policy and technology on sustainable food and fuel supplies in developing countries. In Southeast Asia, he is working with several graduate students on a regional biofuel atlas and household surveys of rural energy use.

David has researched China's economic emergence since the early 1990's, visits the country several times a year, and teaches UCB's main course on the Chinese economy. Recently, his work has focused on China's energy economy, its structural change, and prospects for sustainability. China's pivotal role in global food markets and climate negotiations are also among his active research interests.

At the instance of the Asian Development Bank (ADB), David agreed to establish a research program on the role of infrastructure and economic development. A leading priority for ADB is Asian regional integration, and unprecedented commitments to infrastructure investment are now being made to facilitate this. Like globalization, infrastructure has an intuitive link to aggregate growth, yet its detailed influence on livelihoods, particularly among the region's poor majorities, is not well understood. To elucidate these linkages, David has established a set of eight infrastructure development goals, combined with dozens of metrics to assess progress toward them, that will help ADB and others direct investment resources in ways that are more socially effective.

Finally, David is managing a global research program for FAO on pro-poor livestock policy, with special reference to Highly Pathogenic Avian Influenza (HPAI). Poultry raising is an essential source of nutrition and yields important income for the rural poor across Asia, and the advent of HPAI threatens to displace these producers. David and several colleagues and students are working in Southeast Asia with public health experts to improve smallholder bio-security and help them achieve sustainable market participation.

Teaching remains one of the most satisfying dimensions of David's academic life, and he regularly takes over large upper-division courses on trade, development, and China. "Of course it's exciting to contribute to important policy issues, but I also feel fortunate to bring these insights to my students. For example, reconciling economic and environmental aspirations will be the defining challenge of their generation, and I want them to remember we prepared them for the world they will live in. It will be a changed world, and a world where traditions of affluence and hierarchy will have to change. I tell my students they need not give up their aspirations, but they will have to innovate even more than we have to fulfill them. To sustain the hopes of a larger and more inclusive world economy, we must innovate in resource use, in social awareness, and ultimately in the ethical conduct that offers a means for us to share prosperity."

The Use of Environmental Life-Cycle Analysis for Evaluating Biofuels

Deepak Rajagopal and David Zilberman

Life-cycle analysis (LCA), the methodology used to assess the impact of producing biofuels on greenhouse gas emissions (GHG), may lead to flawed policy implications as it assumes that coefficients could be fixed rather than functions of policies and market forces. The methodology needs to be modified to recognize the effects of prices and changes in technology and policy over time. Fuel quality standards that are based on LCA are likely to be more costly than when controlling GHG emissions by carbon tax or a global cap-and-trade scheme.

Processors that convert corn into biofuel may use two sources of energy—energy from coal and energy from natural gas. An increase in the price of natural gas will lead to a switch to coal, which will result in a significant increase in the GHG generation associated with the production of ethanol.

The biofuel industry, which produces liquid fuels mostly from grain, sugar, and oil crops, emerged to a large extent in response to the rising price of fuels and the increased dependence on fossil fuel produced in politically unstable regions. The impetus for the production of biofuel is also its supposed contribution to a slowdown of climate change. Theoretically, net emissions of greenhouse gases (GHG) from biofuels may reach zero because the carbon emitted while burning was sequestered during photosynthesis.

In reality, however, the production of biofuel requires energy (for fertilizer production, transportation and conversion of feedstock, etc.), and this gives rise to net positive GHG emissions, like other fuels. Thus, the more pertinent question is whether biofuels emit less overall GHG than other fuels. The methodology of life-cycle analysis (LCA) has been used to compare the total energy and the net GHG emissions of various biofuels with that of gasoline or other liquid fossil fuels. Proposed policies suggest relying on LCA to regulate the use of various biofuels.

LCA is a systems approach to evaluating the environmental footprint of industrial processes. The goal behind the development of LCA was to quantify the resource and environmental footprint of industrial activities over its entire life cycle from raw material extraction, manufacturing, and use until ultimate disposal. By resource footprint we mean the total physical flow of both extractive resources such as materials, energy, water, etc. and polluting resources like greenhouse gases, criteria air pollutants, toxic chemicals, etc. through the various stages of the life cycle.

Studies that use LCA to analyze corn ethanol have come to widely different conclusions about the net GHG benefits. Farrell et al., through a meta-analysis of several earlier LCA studies, conclude that corn ethanol generates 0.8 units of GHG for each unit it saves. However, Pimentel and Patzek report that all crop-based biofuels generate more GHG than they save. Such differences notwithstanding, all studies ignore carbon emissions due to land-use change induced by biofuels, and this can be substantial, as we will discuss later. Furthermore, existing studies ignore the response of producers to prices and policies that may affect their input use and thus the GHG of biofuel production.

The lack of consensus in the LCA literature highlights some of the methodological challenges associated with computation of LCA. In the following sections, the current status of LCA and the challenges it faces as a tool for policy-making will be discussed. We present initial results of our research, which aims to compare the implications of alternative life-cycle methodologies, to expand these methods by incorporating economic considerations, and assess the implications of using LCA in policy-making.

Different Types of LCA

It is useful to distinguish between aggregate LCA that uses past data to convey the amount of GHG or other energy or pollutants generated on average in producing one unit of output—be it biofuel or other products in the economy—versus specific LCA that assesses, say, the generation of GHG to produce biofuel at a certain facility. Because of heterogeneity among locations in terms of productivity of

Table 1. Sensitivity of Ethanol LCA to Fuel Mix

	Scenario	Kg. of CO_2 Equivalent Offset per Liter of Ethanol	% Change over Baseline
1	Baseline (Farrell et al. *Science* 2006)	0.18	--
2	Net GHG displacement if average biorefinery uses only coal-based energy	0.09	-50
3	Net GHG displacement if average fertilizer production facility uses only coal-based energy	0.07	-61
4	Net GHG displacement if both the average biorefinery and fertilizer producer use only coal	-0.01	-106
5	Net GHG displacement if average biorefinery uses only gas-based energy	0.42	133

corn, energy used to produce fertilizer, and energy sources for processing ethanol from corn, one expects differences in the GHG footprint of ethanol across locations. While we can get a number that will tell us about the GHG footprint of biofuel production in the past, when it comes to the future, things depend on economic and technological conditions. Thus, the outcome of LCA is not necessarily a number *but, rather, a function.*

To elaborate on this point, note that businesses pursue profits, and their selection of technologies and input use varies according to economic conditions. Processors that convert corn into biofuel may use two sources of energy—energy from coal and energy from natural gas. An increase in the price of natural gas will lead to a switch to coal, which will result in a significant increase in the GHG generation associated with the production of ethanol.

Sensitivity of LCA Calculation to Assumptions

The conclusion of Farrell et al., that on average each liter of corn ethanol produced in the United States displaces 0.18 kilograms of CO_2 equivalent, is based on the assumption that the average conversion facility derives 60 percent of input energy from coal and 40 percent from natural gas. We performed a sensitivity analysis of their model to various assumptions about the relative mix of coal and gas-based energy input to corn conversion and fertilizer production. The results are shown in Table 1.

In the extreme case when both biofuel refineries and fertilizer production shift entirely to coal, there is a net increase in GHG emissions from using corn ethanol compared to gasoline. On the other hand, if, say, in response to a carbon tax the average facility shifts entirely to natural gas, then there is a 133 percent increase in the estimated life-cycle GHG benefit.

This illustrates the fact that the average biofuel's life-cycle footprint is a function of the technology and other input choices of the average producer whose behavior is ultimately influenced by the economic conditions. Thus, LCA numbers are not an outcome of assumptions about technology but also implicit assumptions about behavior and economic conditions. Thus, if government policies and economic conditions are expected to lead to the introduction and adoption of wind power in a biofuel-producing region, then the estimated GHG from the biofuel production are likely to decline. Similarly, LCA studies should be able to assess the gains associated with farm policies that induce adoption of yield-increasing technologies in production of feedstock for biofuel production (improved varieties, precision farming methods, etc.).

Land-use Effects and LCA

LCA was developed to assess the environmental impact of industrial processes, and one of the challenges with regard to biofuels is adapting this technique for agricultural systems. Production of biofuels may either directly or indirectly induce conversion of land from one form of use to another. When biofuel is produced by converting rangeland to farmland, the *direct* land effect is the resulting decrease or increase in carbon sequestration in soil and above-ground biomass. When lands that provided corn for food are converted to biofuels production, the reduced supply of corn will increase corn prices and will lead to expansion of corn acreage, and this extra land has an *indirect* effect on the GHG emission associated with the biofuels production.

A recent study by Fargione et al. finds that producing biofuels by converting forests or rangeland releases 17 to 420 times more GHG than the reduction these biofuels would provide by displacing fossil fuels. Searchinger et al. conclude that if ethanol is produced from switchgrass grown on what was previously corn land, there is a net increase in carbon emissions for up to five decades before there is net sequestration due to global expansion of agricultural land. A closer look suggests that estimating emissions from land-use change is complex for several reasons. The GHG contribution of the cleared biomass depends on how it is managed. This contribution may be smaller when the cleared trees are used to generate power, thus replacing fossil fuel, or converted to products like furniture than when they are burned outright. The indirect effects are complex and

depend on interaction among several markets, innovations in new technologies, and government policies.

Our research considers alternative methods to adapt the LCA method to incorporate land-use changes. The allocation of the initial emissions of land conversion across time will affect the LCA. Emissions will be the highest in the first year when land is cleared but, clearly since this land will produce fuel for several years, one approach is that the emissions should be annualized over the productive time horizon of the land. Since the indirect effect depends on complex economic factors, their incorporation into LCA requires incorporating general equilibrium effects in LCA.

General Equilibrium Effects and LCA

The introduction of biofuel in the United States has expanded total corn acreage but reduced corn available for food. The expanded corn acreage may take land away from wheat, which may move into previously unfarmed land. In Brazil, grazing activity displaced from the Cerrado region by sugarcane expansion may encroach into the Amazon, although sugarcane may not be cultivated in the Amazon. Thus, when one considers the overall effect of producing biofuel on a large scale on net GHG emissions, the indirect land-use effect has to be taken into account. However, calculation of these effects is tricky.

Historically, increased price of food has induced innovations and investments that increased productivity and slowed expansion of agricultural acreage. If rising food prices reduce barriers and accelerate introduction of new high-yield varieties, the land expansion resulting from higher food prices is likely to decline. By lowering gasoline use, biofuels can delay the production of fuels from dirtier sources like tar sands and coal. However, technological lock-in into certain types of biofuels may also hinder development of cleaner alternative fuels.

Table 2. Simulation of Effect of Carbon Tax on Net GHG Emissions from U.S. Corn Ethanol

Carbon Tax ($/Ton)	5	10	15
Percent Increase in Relative Coal Price	17%	35%	57%
Percent Change in Net GHG Benefits per Liter of Ethanol	117%	228%	383%

Such intricate linkages call for careful interpretation of current LCA numbers. If one conducts LCA on activities that are done on a relatively small scale or products with small markets, then general equilibrium effects can be ignored. However, if an aggregate LCA is considered, then the secondary effects associated with change in prices have to be taken into account.

When conducting a general equilibrium analysis to assess the aggregate GHG impact of biofuel, especially when looking at the future, one has to recognize that this effect depends on policies. Introduction of policies that will invest in research to improve the productivity of biofuel and the efficiency of processes that convert them to fuels, or policies that will enhance adoption of biotechnology of similar productivity-enhancing technologies in traditional agriculture, may lower the impact of biofuel on GHG.

LCA as a Policy Tool: Application of the Low-Carbon Fuel Standard (LCFS) in California

When used as a regulatory tool, LCA can be used to develop policies that would permit fuels below a threshold value for net carbon emissions to be sold in a market, while keeping others out. The LCFS is a first-of-a-kind policy adopted by California, which stipulates GHG emissions per unit of fuel to be below a maximum value which is set to decline over time. This is expected to lead to an introduction of different blends of fuels that will meet GHG standards. LCA indicators, if calculated correctly, can aid the implementation of such a standard. It will also have significant regulatory costs because, to do it right, one will have to trace all the processes that were involved in generating certain fuels and to calculate the GHG emissions.

The uncertainty in calculating the LCA indicators notwithstanding, such a policy is prone to gaming when implemented regionwide or nationwide as opposed to being worldwide. The end result may be reallocation of existing clean and dirty fuels between the various regions, depending on the level of regulation. However, when the region imposing the policy is a large player in the market, this can indeed improve the environmental quality of the average fuel mix.

An alternative approach is to impose a carbon tax where one pays for the carbon content of the fuel they burn. However, since the drawback here is that the upstream carbon associated with transporting gasoline from the Middle East to California or producing biofuel is not taxed, LCA can be used to calculate a more accurate carbon footprint for the fuel at the point consumption. On the other hand, a global carbon tax that pervades all industries and their activities worldwide obviates to a large extent the need for a complex, dynamic general equilibrium LCA. Nevertheless, an LCA model that is a function of prices can be useful in predicting the changes in GHG emissions resulting from a carbon tax.

In Table 2 we simulate the effect of a carbon tax on the relative price of coal with respect to natural gas, which in

The low-carbon fuel standard (LCFS) is a first-of-a-kind policy adopted by California, which stipulates GHG emissions per unit of fuel must be below a maximum value which is set to decline over time. This is expected to lead to an introduction of different blends of fuels that will meet GHG standards.

turn can be expected to induce a shift toward greater use of natural gas and lesser use of coal by the ethanol-processing industry. Since gas is a less carbon-intensive fuel compared to coal, this shift will on average increase the GHG benefits per liter of ethanol.

Conclusion

Biofuels are being introduced with the aim of enhancing energy supply and reducing GHG emissions. The impact on the former is clear, while that on the latter is uncertain. LCA, the preferred method today for estimating the latter, has become an important tool in the design, implementation, and measurement of policy impacts toward biofuels. Our conclusion is that LCA is a construct that is valuable but prone to misuse and to errors.

Our analysis suggests further methodological development such as the inclusion of price effects, dynamics of carbon emissions and technological change, general equilibrium effects, and a distinction between marginal and average effects before it is employed as a decision-making tool by policy makers. Policy makers should also consider non-GHG environmental impacts that would result from biofuels which has not received much attention in the LCA literature. We also believe that fuel quality standards based on LCA are likely to be more costly than controlling GHG emissions by a carbon tax or a global cap-and-trade scheme.

Deepak Rajagopal is a Ph.D. candidate in the Energy and Resources Group, UC Berkeley, and David Zilberman is a professor in the Department of Agricultural and Resource Economics, UC Berkeley. They can be contacted by e-mail at deepak@berkeley.edu and zilber@are.berkeley.edu, respectively. *The research leading to this publication was supported by a grant from ERS, USDA, and EBI.*

For more information, the authors recommend:

Fargione, J., Hill, J., Tilman, D., Polasky, S., & Hawthorne, P. (2008) "Land Clearing and the Biofuel Carbon Debt," *Science*, DOI: 10/1126/science.1152747.

Farrell, A. E., Plevin, R. J., Jones, A. D., O'Hare, M., & Kammen, D. M. (2006) "Ethanol Can Contribute to Energy and Environmental Goals," *Science* 311, 506-508.

Pimentel, D., & Patzek, T. (2005) "Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower," *Natural Resources Research* 14(1), 65-76.

Rajagopal, D., & Zilberman, D. (2008) "Incorporating Price Responsiveness into Environmental Lifecycle Assessment." Paper presented at the conference on The Lifecycle Carbon Footprint of Biofuels, Miami, Florida.

Searchinger, T., Heimlich, R., Houghton, R. A., Dong, F., Elobeid, A., Fabiosa, J., Tokgov, S., Hayes, D., & Yu, T.-H. (2008) "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change," *Science*, 319, 829b.

Enhancing Producer Returns: United Potato Growers of America

Shermain D. Hardesty

United Potato Growers of America was formed in 2005 to stabilize and increase grower prices. As a federation of regional cooperatives, it has implemented voluntary supply-control measures to better match potato supplies with demand in the U.S. fresh potato market.

United Potato Growers of America (UPGA) members produce approximately 70 percent of the nation's fresh market potatoes.

Facing prospects for continuing depressed market prices, Idaho potato growers formed a cooperative, the United Potato Growers of Idaho, in November 2004. Its leaders then quickly mounted efforts to broaden the development of supply-management programs into other major potato-producing states; several regional cooperatives were formed. In March 2005 the United Potato Growers of America (UPGA) was created as a federation of these regional cooperatives to enhance the profitability of U.S. potato growers. Its mission statement reads: "We bring order and stability to the North American potato growing industry and increase our member potato growers' economic potential by the effective use of cooperative principles."

As of November 2007, UPGA had ten member cooperatives that include growers from California, Colorado, Idaho, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Washington, and Wisconsin. These members produce approximately 70 percent of the nation's fresh-market potatoes. One of its members is a California cooperative, Kern Produce Shippers Association. Another member, United Potato Growers of Canada, represents 96 percent of Canadian potato acreage; it was formed in 2006 with support from UPGA. As a foreign entity, it participates with UPGA through a memorandum of understanding and through at-large individual memberships.

As described below, UPGA operates as an "enhanced" information-sharing cooperative. It has implemented an information-based strategy to control supplies in order to restore orderly marketing conditions. There are three main components of UPGA's volume control program:

- ***Planting controls***

All member cooperatives have developed acreage-reduction programs. UPGA members are randomly audited to verify compliance with adopted planting guidelines.

- ***Market data reporting and analysis***

UPGA maintains an online data reporting system where members report shipments and prices received. Seven years of data have been used to predict the effect of shipments on future prices.

- ***Product flow controls***

Transitions between seasons are managed by balancing storage volumes and new crop estimates in order to protect fresh crop values.

UPGA establishes a floor price for the marketing season. Based on its analysis of the impact of weekly shipment volumes on prices, UPGA develops weekly target shipment volumes and uses volume controls to keep prices above its floor price.

UPGA's chief operating officer, Buzz Shahan, describes the members' weekly conference calls as a "market conversation." As a young organization, UPGA provides a classic demonstration of the power of producer collaboration through the cooperative structure to increase and stabilize grower returns. The economic factors underlying this effort are examined below. To better understand the framework surrounding UPGA, a brief overview of the U.S. potato industry is provided first.

Overview of U.S. Potato Industry

Idaho is the nation's leading producer of potatoes, with 29 percent of total production in 2006. Nine other states—Washington, Wisconsin, North Dakota, Colorado, Minnesota, Oregon, Maine, Montana, and California—produced an additional 59 percent of the U.S. potato crop. Nationally, yields have soared, rising from 231 hundredweight (cwt.) per acre in 1971 to 393 cwt. per acre in 2006.

Between 1971 and 1996, per capita consumption of potatoes rose from 117.8 lbs. to 145.0 lbs.; much of this growth was attributable to sales of french fries in the fast food sector. Since then, per capita potato consumption declined to 130.2 lbs. in 2006. Only 19 percent of potatoes were processed in 1959; by 2005, potato consumption had shifted significantly into processed forms with 56 lbs. per capita used annually for frozen potatoes, 45 lbs. for

Figure 1: Annual Average Prices Received by Potato Growers

Source: USDA-Economic Research Service.

fresh potatoes, 17 lbs. for potato chips, and 16 lbs. for dehydrated products.

Potatoes can be marketed interchangeably in both the fresh and processing markets because of their physical characteristics and storability. Fresh-market potatoes are sold mostly on the open market; typically, the residual supply is sold to dehydrators. Processing potatoes, such as Russet Burbanks, are usually contracted to commercial fryers before planting. These contracts specify the potato variety, volume, and price based on quality requirements. The Potato Marketing Association of North America represents producers in their bargaining negotiations with processors; its member bargaining associations include producers from Washington, Southern Idaho, North Dakota, Wisconsin, Minnesota, Maine, and several Canadian provinces.

Under normal market conditions, prices are highest in the fresh-market (Figure 1). Since 1980, real prices (in deflated 2000 dollars) declined from $12.12 to $5.04 per cwt. in 2006. Joseph Guenthner, an agricultural economist at the University of Idaho, determined that Idaho fresh growers averaged a loss of $2.67 per cwt. on their production in 2000, when fresh (nominal) market prices averaged $5.27 per cwt. Such poor market conditions forced producers to seek ways to improve prices.

Economic Factors Underlying UPGA's Programs

There are several economic factors underlying UPGA's programs. Consolidation in the grocery, foodservice, and food manufacturing sectors has contributed extensively to growers' loss of market power. According to Guenthner, three processors—Lamb Weston, McCain, and Simplot—represented 83 percent of the total frozen potato market in 2000, compared to a 55 percent market share for the top three processors in 1980. In the grocery sector, the top three firms had a 28 percent market share in 2003.

Given the highly concentrated nature of the potato processing industry, individual potato growers and shippers have less market power than their large customers. The Capper-Volstead Act provides authority for farmers to join together in cooperative associations to gain countervailing market power without violating antitrust laws, as long as they do not unduly enhance prices. Cooperatives enable producers who are facing imperfect markets to regain market power by collaborating with, rather than competing against, each other when dealing with processors and other customers.

Due to their declining numbers, it has become easier for potato growers to organize themselves. For example, the number of potato farms in Idaho decreased from 1,435 to 818 between 1997 and 2002, while average acreage increased from 229 to 445 acres.

Information is critical for efficient economic markets. As noted by UPGA's chief operating officer, "Information changes behavior." The improved information flow that UPGA has developed enables producers to allocate their production resources more efficiently and to better understand the potential impact of their shipments on current and future market prices. Furthermore, better information allows buyers and sellers to make transactions with less product waste and lower costs for capital and labor.

The interrelated nature of various potato market sectors makes the improved information flow even more valuable. For example, UPGA's planting guidelines assist seed potato producers in determining how much they need to grow. The cooperative structure facilitates this improved information flow.

The inelastic demand for numerous staple commodities, including potatoes, has been well documented. This concept is essential to UPGA's use of supply controls. When demand for a commodity is inelastic, restricting supply is a classic economic tool used to raise grower prices and revenues. This is possible because the resulting percentage increase in price is greater than the percentage decrease in quantity sold, resulting in an overall increase in grower revenues.

UPGA's Volume Controls

Since demand for potatoes is inelastic, UPGA has been able to implement four types of volume control mechanisms to enhance producers' revenues.

By imposing acreage limitations, UPGA is controlling production volumes. Members are randomly audited

to verify compliance with these controls.

UPGA is utilizing market flow controls (pro-rates) during season transitions to ensure that oversupplies in the market do not put downward pressure on current and future prices. The effectiveness of these controls is strengthened by the inclusion of the United Potato Growers of Canada in UPGA; Canada historically has been an important supplier in the U.S. fresh potato market.

Market allocation programs are used to limit product volumes to primary markets and to coordinate the flow of the balance of the supplies into secondary markets. UPGA is collaborating with growers, processors, and industry organizations involved in all of the major U.S. potato market sectors—fresh, frozen, chip, dehydrated, and seed. It has already convinced dehydrators to contract for most of their potatoes, rather than gambling on culls diverted from the fresh market. Such efforts enable UPGA to better control overall potato plantings.

Establishing more rigorous grades and standards reduces potential market supplies and can increase buyers' willingness to pay higher prices due to improved product quality. Some UPGA member cooperatives have increased minimum size requirements for fresh market potatoes.

Conclusions

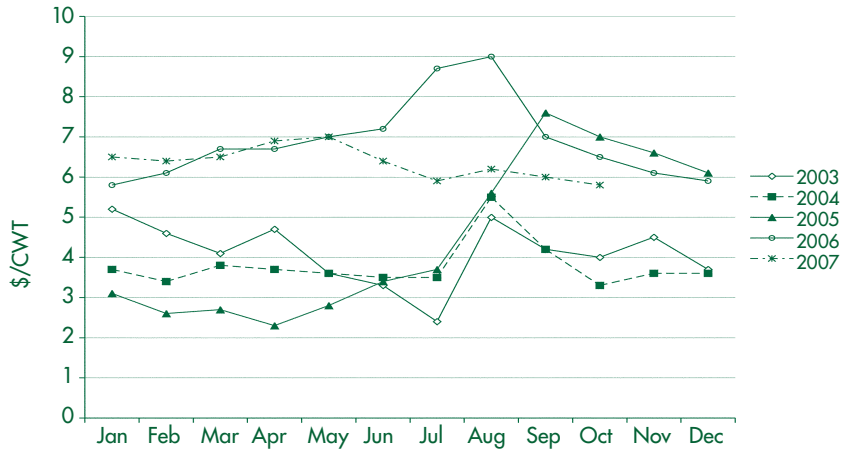
UPGA quickly developed and implemented an information-based supply management program. The results of its efforts are displayed in Figure 2. Monthly average prices received by Idaho growers in the fresh market are higher and noticeably more stable than before UPGA's implementation of supply controls in Fall 2005.

Because it is a voluntary organization, UPGA has to contend with the "free rider" problem; nonmember producers benefit from the higher and more stable prices achieved without having to reduce their acreage and control their sales flows. UPGA's leadership is addressing the "free rider" problem by impressing upon nonmembers the need for compliance with UPGA's controls and the significant additional benefits that could be derived by all producers from such cooperation. It is also seeking to broaden its membership to other important fresh-market states, such as Maine.

It should be noted that federal marketing orders can be utilized to impose volume controls on all growers, although they cannot be used for the purpose of setting floor prices. However, cooperatives in several industries have engaged in legal price setting and then utilized marketing orders as a complementary tool to subject all growers to mandatory volume regulations, thus eliminating the "free rider" problem.

Supply management through enhanced information sharing is a powerful economic tool for increasing returns to agricultural producers. The cooperative structure is an accepted organizational structure for implementing such programs. For over thirty years, central California lettuce producers have operated an information-sharing cooperative; its members agree to sell all of their lettuce at prices within the limits of floor and ceiling prices set by the cooperative. When market prices plummeted after California's citrus marketing orders were eliminated, industry leaders organized themselves into a cooperative to legally share information and regain market power. Recently, UPGA has shared its experiences with egg and mushroom producers. It is likely that producers of other agricultural commodities will also explore using joint action by forming information-sharing cooperatives to improve their market conditions.

Figure 2: Grower Price Received: Idaho Fresh Market Potatoes



Source: USDA-National Agricultural Statistics Service

Shermain D. Hardesty is a Cooperative Extension economist in the Department of Agricultural and Resource Economics at UC Davis and serves as the director of the University of California Small Farm Program. She can be contacted by e-mail at shermain@primal.ucdavis.edu.

For additional information, the author recommends:

Guenthner, Joseph F. Gaining Market Power Through Grower Consolidation, Intellectual Property Rights and Human Capital. http://www.fchorizons.com/uploads/guentherRP.pdf.

Agricultural and Resource Economics UPDATE

Co-Editors

Steve Blank
David Roland-Holst
Richard Sexton
David Zilberman

Managing Editor and Desktop Publisher

Julie McNamara

Published by the Giannini Foundation of Agricultural Economics

http://giannini.ucop.edu

ARE Update is published six times per year by the Giannini Foundation of Agricultural Economics, University of California.

Domestic subscriptions are available free of charge to interested parties. To subscribe to **ARE Update** by mail contact:

Julie McNamara, Outreach Coordinator
Department of Agricultural and Resource Economics
University of California
One Shields Avenue, Davis, CA 95616
E-mail: julie@primal.ucdavis.edu
Phone: 530-752-5346

To receive notification when new issues of the **ARE Update** are available online, submit an e-mail request to join our listserv to julie@primal.ucdavis.edu.

Articles published herein may be reprinted in their entirety with the author's or editors' permission. Please credit the Giannini Foundation of Agricultural Economics, University of California.

ARE Update is available online at http://www.agecon.ucdavis.edu/extension/update/

The University of California is an Equal Opportunity/Affirmative Action employer.

Agricultural and Resource Economics UPDATE
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS • UNIVERSITY OF CALIFORNIA

Department of Agricultural and Resource Economics
UC Davis
One Shields Avenue
Davis CA 95616
GPBS