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Indirect Land Use: One Consideration Too Many in Biofuel Regulation

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Allocation of agricultural commodities like corn to produce biofuels (ethanol)—leads to higher corn prices, which may lead to expansion of corn acreage and ultimately expansion of agriculture resulting in extra greenhouse gas (GHG) emissions from land use. These extra emissions are what are referred to as indirect land-use effects (ILUEs) of biofuels. This paper argues against the current practice of considering ILUEs of biofuels in the current California and Federal regulations of biofuel. The indirect land uses are uncertain, vary over time, and their current estimates diverge significantly.

Also in this issue

Can Improved Market Information Benefit Both Producers and Consumers? Evidence from the Hass Avocado Board's Internet Information Program

Hoy F. Carman, Lan Li, and Richard J.Sexton.............................5

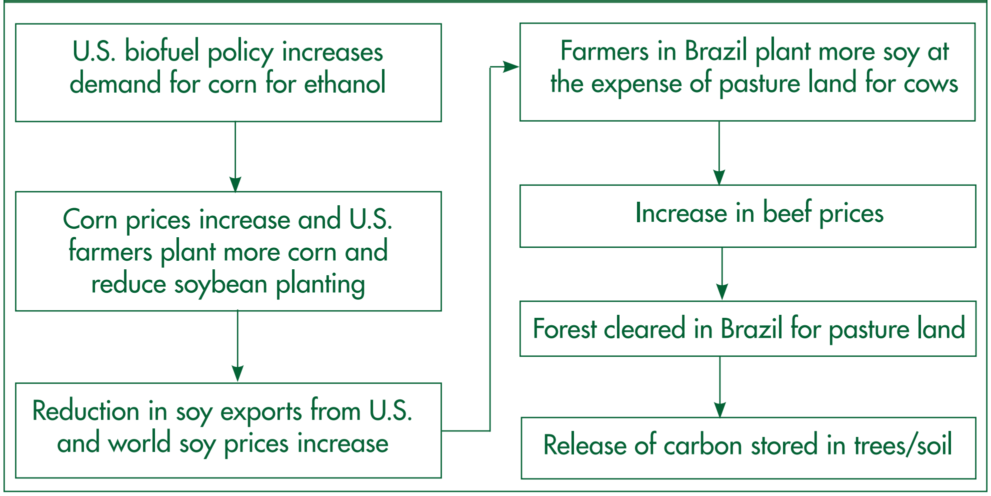
End of Life Vehicles and Air-Conditioning Refrigerant: Can Regulation Be Cost Effective?

Emily Wimberger and Jeffrey Williams................................9

One of the major objectives of renewable fuel policies in the United States is to introduce alternative fuels that reduce greenhouse gas (GHG) emissions relative to fossil fuels. Thus, the Energy Independence and Security Act of 2007 (EISA) requires that transportation fuels sold in the United States contain a minimum volume of biofuels and requires a national renewable fuel standard (RFS). Enforced by the U.S. Environmental Protection Agency, the RFS sets an upper bound on GHG emission per unit of various biofuels. For example, corn ethanol meets the RFS if (after the appropriate adjustments) it reduces the GHG emission by 20% relative to gasoline. Another major regulation of biofuels is the low carbon fuel standard (LCFS), which, unlike the RFS, concerns all fuels. It was introduced by California as part of AB32 and is under consideration by other states and also the EU and China. The California standard requires reduction of the average GHG emission of fuels by a certain percentage each year until attaining the eventual target of 10% reduction by 2020.

The GHG emission of different fuels in these regulations is calculated using life cycle analysis (LCA). Traditionally, this technique calculates all the emissions that are generated throughout the life of a biofuel, including the emissions generated in production of fertilizers, plowing of the fields, harvesting, processing, as well as burning of the fuel. However, a unique feature of biofuel regulation is that the traditional LCA is augmented to account for the indirect land-use effects (ILUEs) associated with the production of biofuel. For example, if producing biofuel from corn led to the expansion of agricultural land and conversion of rangeland or forest to agriculture, this ILUE is considered as part of the LCA. One possible pathway leading to land-use change is shown in figure 1 on page 2. The idea that biofuel regulations needs to take into account the ILUE was motivated by an influential paper by Searchinger et al. (2008). This notion is based on the basic properties of market behavior. In particular, when the demand for a product like corn is expanding, in our case because of the introduction of biofuels, the increase in the price of the product leads to increased supply. The increased supply of corn may lead to land conversion to agricultural production, and this process of expanding the agricultural land base leads to release of extra GHG emissions. These extra GHG emissions have to be calculated as they are the indirect land-use components of the LCA of biofuels. Figure 1 provides a graphical presentation of the LCA and the indirect land uses of biofuels. While including ILUEs in assessing the impact of biofuel seems appealing, we will argue here against an indirect land use in biofuel regulations for the basic reason that its inclusion in LCAs contradicts a basic principle of regulation—namely that individuals

Figure 1. One Pathway for Indirect Land Use Change



are responsible only for actions that they control. The indirect land uses are difficult to compute and vary over time. Finally, there are other indirect effects of biofuels that are not included in the LCAs of biofuel, and thus the inclusion of indirect land use is inconsistent with other regulatory criteria.

Use of Indirect Land Use Contradicts the Sound Principle of Policy Design

The technical difficulty in estimating indirect land use is only one reason why this concept is not appropriate to use in regulating biofuels. Economists introduced the notion of an externality. It occurs when the activities of one economic agent, say a farmer, has an unintended effect on the well-being of others. They distinguish between technical and pecuniary externalities. Negative technical externalities occur when, for example, waste materials from farms contaminate the water of a nearby fishery. In this case, economic theory suggests it is socially desirable that the polluters will take into account the extra contamination cost in choosing their activities.

Pecuniary externalities occur when the activities of a group of economic agents affect the well-being of others through markets by changing prices. When the industry is competitive—and, for example, when a group of economic agents increases their demand for a product, the price of the product increases, and more of the product will be produced. Other buyers of the product will suffer from the pecuniary externality (the price increase). Economic theory suggests that the industry shouldn't be responsible for the impact of the rising prices. Moreover, if the increase in production will result in more pollution, namely a technical externality resulting from the pecuniary externality, then economic theory suggests that policy intervention should be enacted to modify the polluting activities of the producers of the extra supply.

The difference in the treatment of technical and pecuniary externalities is that producers control their production and hence their pollution. But in a competitive market, they don't control the prices. This reflects a basic principle: Individuals should be responsible for activities that they control and not for those that they don't.This basic message of accountability suggests that producers of biofuel shouldn't be held responsible for indirect land-use decisions made by others.

The use of a traditional LCA for environmental regulation is justified on informational and control considerations. The production of biofuel may involve supply chains with many entities that are vertically linked through contractual arrangements. When the final seller of biofuel, say an oil company, is held accountable for the life cycle emission, it may be much more effective in obtaining information and affecting choices throughout the supply chain than a government entity when it attempts to regulate each entity separately. Holding the final seller of a supply chain responsible for emissions and other externalities throughout the supply chain is a growing tendency that has led to increased emphasis on traceability and resulted in regulations based on LCA in other sectors of the economy. While the sellers of the biofuels are aware and can affect the behavior of their suppliers and other agents up the supply chain, they cannot affect the choices of producers in another industry (farmers in Brazil), and the indirect land use lacks one of the advantages of the use of traditional LCAs in regulating biofuels.

Furthermore, there is a related flaw in the use of indirect land use for regulating biofuels. Basic principles of public economics suggest that all emitters of GHGs in the world are held responsible for their own activities. The indirect land-use approach holds farmers responsible for possible emissions by farmers elsewhere. Searchinger et al.'s arguments imply that since the Brazilian government may not fully control deforestation in the Amazon, we should make sure that U.S. biofuel producers would be held responsible for activities that will raise the price of corn and soybean and may lead agents in Brazil to deforest the Amazon and increase GHG emissions. It makes more sense to strive to enact policies that will make Brazil, or any other country, responsible for the GHG emissions associated with land-use changes in their countries through international agreement, rather than make agents in the United States, or elsewhere, responsible for the lack of action in Brazil. It is impractical to assume that by modifying the biofuel policies in the United States, one can forever protect the tropical forests in Brazil or anywhere. There is an old principle of policymaking that each policy tool should concentrate on controlling a policy objective. When LCA regulations aimed to control the choices of biofuel suppliers to the U. S. market, and also are designed, at least implicitly, to affect land-use choices of other agents, they are likely to underperform in all tasks. Biofuel policies are part of a set of land-use policies that try to achieve multiple objectives including control of GHG, preservation of biodiversity, provision of environmental amenities, and production of food and fiber within a globalized economy. Whenever market prices do not capture social costs or benefits, specialized policies should be designed to address the technical externalities of biofuels, land-use expansion, and biodiversity preservation.

The ILUEs of Biofuels Change Frequently and Are Difficult to Implement

Recent attempts of computing the ILUEs of biofuels have encountered some problems. First, different studies derived significantly different estimates of the ILUEs. For example, a forthcoming study by Hertel et al. (2010) estimates the magnitude of the ILUE of biofuel to be one-third of the one estimated effect by Searchinger et al. (2008). This is not surprising since the computed change in land use and emission of GHGs is based on responses to commodity prices, which are diverse and have varied drastically between countries and among crops over time. Higher commodity prices may lead to increased agricultural acreage and/or intensification of agricultural production by adoption of more efficient production technologies or increase in the use of inputs like fertilizers. Land-use changes are more likely to contribute significantly to increased overall agricultural supply in periods of low rates of change in agricultural productivity and be less important in periods of large gain in productivity. The recent study by Alston, Beddow, and Pardey (2009) suggests that the changes in agricultural productivity vary significantly among regions and over time.

Further, changes in productivities are strongly affected by policy. Zilberman et al. (1991) suggest that banning the use of pesticides, for example, might have led to a strong increase in acreage, as yield per acre would have declined. A recent study by Sexton and Zilberman (2010) suggests that the adoption of genetically modified (GM) corn, soybeans, and cotton increased yield substantially. In the absence of this productivity increase, acreage would have been rising. They calculate that without the adoption of GM crops, some prices of agricultural commodities, like corn, would have risen by 30%. They also argue that if the practical ban of biotechnologies in European and African countries had been removed, much of the increase in food prices attributed to biofuels would have been eliminated. Historically, agricultural production has grown much faster than arable land. According to Federico (2009), the world agricultural production more than tripled between 1950 and 2000, while acreage in arable land and tree crops grew by less than 25%. U.S. agricultural acreage peaked around 1920 and, even though productivity output has increased by ten- fold since then, the acreage has declined.

Computation of the ILUE does not end in estimating the expansion of agricultural land because of biofuel. It requires quantitative understanding of the conversion of various ecosystems (forest and pasture) to agriculture and their implications on GHG. There is a big difference from the GHG perspective whether an increase in the acreage of corn would result in conversion of old-growth forest or wildland to farming. Some of the increases in soybean acreage in South America in recent years were "virtual" increases, namely farmers started double-cropping soybeans following wheat, which might have led to carbon sequestration and reduce GHG emissions. The uncertainty about the conversion of ecosystems to farming is a major reason for the differences between indirect land-use estimates. However, the conversion processes and their GHG implication can be affected by policies and technologies. Better enforcement of policies to control deforestation, as well as incentives for carbon sequestration, may drastically affect the GHG impact of agricultural expansion because of biofuels.

Thus, it would be very difficult to predict the ILUEs of specific biofuels as they are unstable—affected by changes in weather, economic conditions, and knowledge. They can also be influenced by policy choices; for example, more investment in agricultural research, more liberal regulation of biotechnology, or changes in the deforestation and land-use policies.

Consistency and Incentive Considerations

The introduction of indirect land use in the context of biofuel is inconsistent with other types of policies. The introduction of biofuel has other indirect effects through the markets. For example, one can consider the indirect fuel price effects associated with biofuel. Recent studies suggest that the introduction of biofuel has reduced the price of fuels by 1–2%, which results in extra driving and an increase in congestion and GHG emissions. On the other hand, by reducing the price of fuel, the introduction of biofuel may make it less profitable to invest in oil produced from tar sands and to convert coal to oil. This may reduce GHG emissions because conversion of tar sands for oil is highly contaminating. Furthermore, the increase in supply of biofuels may lead the Organization of the Petroleum Exporting Countries (OPEC) to reduce some of their production activities.

And again, the indirect effect through the markets also affects GHG emissions.

So, if we start to consider some indirect effects on GHGs associated with biofuel, we should consider them all. But, then where lies the end? And how can we calculate them all? Why should we hold producers responsible for things that they cannot control? There is another source of inconsistency that one has to recognize when considering indirect land use. The conservation reserve program (CRP) in the United States, and other reserve programs are improving environmental qualities—and providing a significant amount of ecosystem services by diverting land from agricultural production and, in many cases, the production of corn and soybean. By taking corn and soybean out of production, the CRP has indirect land-use effects that may lead to expansion of production in other parts of the world with negative environmental impacts. Are these ILUEs taken into account when farmers' proposals for diversion of land through CRP are evaluated?

Biofuels, to a large extent, are works in progress. Our methods of crop production, processing, conversion, and utilization of biofuels are far from perfect. We rely on first-generation biofuels that, in some cases, may generate more GHG emissions than they sequester. However, at the same time, we aim to encourage technological development that will improve the GHG performance of existing biofuels, which leads to introduction of more sustainable second-generation biofuels. We allocate a large amount of public research, but these technologies will not be improved and introduced without major private investment. The introduction of biofuel plants is subject to incentives and regulations, and it is expected that the GHG performance of the new facilities will be far superior to that of the current facilities.

However, indirect land uses introduce uncertainty because the performance standards under which new facilities will be judged will not be controlled by their own design, but by the performance of other actors that they cannot control. Increased uncertainty is a disincentive for investment, and indirect land use may inadvertently lead to underinvestment in second-generation biofuels or improvement in current biofuels. From an investor's perspective, it may be more sound to have policies that become stricter over time than policies that are inherently uncertain. Thus, the indirect land use that is part of the attempt to reduce GHG effects of biofuels may have the opposite effect by providing this incentive to invest in new and cleaner biofuel technologies.

Conclusions

The indirect land-use concept reflects good intentions, but has many practical and logical flaws. When individuals are regulated based on the indirect land use of their biofuels, they become responsible for actions that they do not control. Current policies are inconsistent since they consider one type of indirect effect of biofuels while ignoring others. The ILUEs of biofuels are unstable, may vary significantly over time and with policy choices, and are difficult to implement. Their inclusion in biofuel regulations introduces unnecessary uncertainty about future regulations, which hampers investment choices. Thus, the use of indirect land use in the current regulations of the GHG emissions of biofuels represents a well-intentioned, unilateral effort to control one aspect of climate change, but it may be counterproductive.

Removal of ILUEs from LCAs will present an improvement of biofuel regulations. But stand alone, biofuel or renewable fuel policies not integrated with controls of other GHG emissions, are far from ideal. Climate change is a global problem requiring consistent policy responses throughout the world. Efficient control of climate change requires equilibrating the implied prices of GHG emissions across activities. Designing procedures and mechanisms to further improve biofuel utilization and prices is an important subject for future research and policymaking.

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Can Improved Market Information Benefit Both Producers and Consumers? Evidence from the Hass Avocado Board's Internet Information Program

Hoy F. Carman, Lan Li, and Richard J. Sexton

We estimate benefits to consumers and avocado producers of the Hass Avocado Board's market-information program. Evidence suggests that the program stabilized shipping point prices, reduced the farm-retail marketing margin, and conferred benefits to both consumers and producers.

Retail margins for avocados will tend to increase with larger and more frequent price changes, and decrease with smaller and less frequent price changes.

The Hass Avocado Board (HAB) is a U.S. government-sponsored marketing program funded by a producer assessment of 2.5 cents per pound on all domestically produced and imported Hass avocados sold in the U.S. market. While the HAB allocates the majority of its funds to advertising and promotion programs, it also conducts an innovative Internet information program through its Network Marketing Center. Growers, packers, shippers, and wholesalers in the United States, Chile, Mexico, Dominican Republic, and New Zealand, as well as U.S. retailers, have access to the HAB web site where they share marketing information, including harvest, shipment, and price data. The "orderly marketing" goal of information exchange is to smooth shipments to major U.S. markets, prevent seasonal surplus and shortage situations, and promote stable shipping-point and retail prices.

Government market-information programs have been justified based on their contributions to improved market outcomes, especially when there are significant differences in market power between buyers and sellers. However, the availability of timely information has decreased over time as marketing channels for agricultural products have become more direct, replacing central wholesale markets. Government budget issues and a lack of reliable estimates of the benefits of market-information programs have also contributed to their elimination. Now, however, advances in communications and information technology provide a framework for innovative and effective market-information programs.

The HAB information program is an example of one such program. In this article we estimate the impact of the HAB program on shipping-point price variability and avocado marketing margins. Costs and benefits of the program to both consumers and Hass avocado producers are estimated.

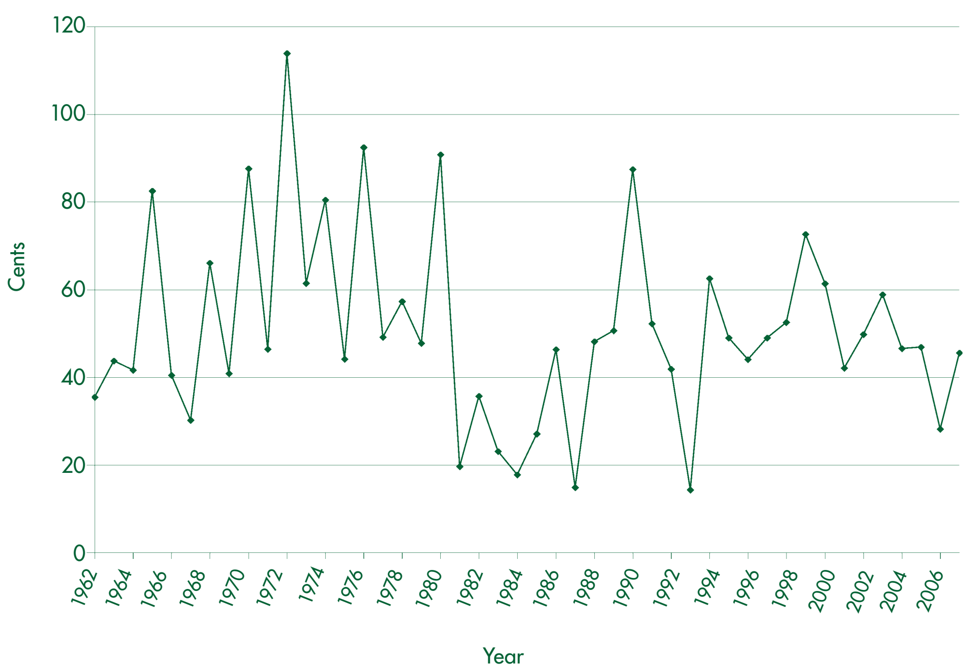
Analytical Framework

U.S. supermarkets have market power that is evident in their pricing practices. An analysis of price transmission for avocados found that retail prices for avocados respond more fully to shipping-point price increases than to shipping-point price decreases. Specifically, Li estimated that, on average, 76% of an increase in shipping-point price is passed on to retail, compared to only 29% of a decrease in the shipping-point price. As a result, retail margins for avocados will tend to increase with larger and more frequent price changes, and decrease with smaller and less frequent price changes.

Price instability thus promotes higher retailer margins, and increased price stability will tend to decrease annual average retailer margins. Information programs that smooth the flow-to-market of avocados, stabilize prices, and reduce marketing margins can benefit both producers and consumers through higher average shipping-point prices and lower average retail prices.

To estimate the impact of price variability on avocado marketing margins, we proceeded as follows: (1) the variance and standard deviation of weekly shipping-point prices before and after initiation of the HAB information program were calculated and compared;

Figure 1. Inflation-adjusted Annual Average California Shipping-point Price for Avocados, 1962–2007



(2) using Li's estimates of marketing margin adjustments to shipping-point price changes, the estimated average annual change in the standard deviation of weekly prices after program initiation was used to simulate weekly changes in estimated marketing margins; and, (3) using estimated price elasticities of demand, the changes in estimated marketing margins were allocated between the retail and shipping-point levels in the marketing channel.

Results

Information for the analysis is from the Avocado Marketing Research and Information Center (AMRIC) system. AMRIC, created by California law in 1985, provides the California avocado industry with daily inventory and shipment information to guide harvest/market strategies. AMRIC has developed a strong database on avocado prices and inventories by variety and size, as well as shipments by major market destination, variety, and size.

Avocado Price Variability: The HAB information program was initiated during the 2002–2003 marketing year. The variance and standard deviation of weekly California shipping-point avocado prices were calculated for each year of the ten-year period 1998 through 2007. This period was selected to include the five years before (1998 through 2002) and the five years after (2003 through 2007) initiation of the HAB information program.

The real (inflation-adjusted) annual average California shipping-point price for avocados is shown in figure 1 for 1962–2007. Annual average prices mask considerable intrayear variability in prices. The standard deviation of weekly average prices for the most recent five years, 2003–07, averaged 0.2045, a decrease from the weekly average standard deviation of 0.2843 for the prior five years. Thus, the average annual standard deviation of weekly prices decreased 28% from the five years immediately before initiation of the HAB information program to the first five years after initiation of the information program. At the same time, the annual average standard deviation of California weekly shipments increased from the first five years (1998 through 2002) to the most recent five years (2003 through 2007), while the standard deviation of total weekly shipments (California plus all imports) decreased.

This indicates that coordination of imports with California shipments has smoothed total weekly avocado shipments and prices during the marketing year. While growing imports had the potential to introduce additional quantity and price variability into the U.S. market, the opposite has occurred. Imports have been timed to maintain a rather steady flow of avocados to retail markets, which tends to stabilize prices at both the shipping-point and retail levels. A portion of the smoothing of quantity and prices

Table 1. Estimated Total Annual Changes in Gross Margins for Hass Avocados, Average Shipments, Standard Deviation of Price, and Average Price, 2003-2007

	Year				
Item estimate	**2003**	**2004**	**2005**	**2006**	**2007**
Margin change ($)	6,533,780	2,889,059	8,133,135	4,033,952	10,070,172
Ave. weekly shipments (lbs.)	8,512,807	11,771,751	12,484,837	15,194,896	13,361,154
Std. deviation of price ($/lb.)	0.271	0.128	0.216	0.058	0.263
Average weighted shipping point price ($/lb.)	1.136	1.018	0.955	0.761	0.993

Source: Calculated from weekly price and shipment data provided by the California Avocado Commission Avocado Marketing Research and Information Center (AMRIC).

as imports increased significantly can, and should be, attributed to the active HAB information programs.

Marketing Margin Adjustments: The results from Li's research on price transmission in the marketing channel were used to estimate weekly changes in gross marketing margins between the shipping-point price and the retail price of avocados. We assumed that 76% of the increase in shipping-point prices was passed on in the form of higher retail prices and 29% of a decrease in shipping-point prices was passed on to consumers in the form of lower retail prices. The changes in estimated gross marketing margins from week to week are based on total weekly shipments, the change in average weighted shipping-point price per pound for all Hass avocados, and Li's estimated adjustment ratios.

Annual estimated gross changes in marketing margins, based on each marketing year's weekly total Hass avocado shipments and weighted weekly average Hass avocado shipping-point prices, are shown in table 1. The actual annual standard deviations of weekly Hass avocado shipping-point prices both decrease and increase from year to year, ranging from a high of 0.271 in 2003, the first year of the information program, to a low of 0.058 in 2006, a year of record weekly shipments due to a very large California crop. Estimated total changes in marketing margins associated with shipping-point price changes vary from $2,889,059 in 2004 to just over $10 million in 2007. Note that the total changes in marketing margins are positively related to average weekly shipments and the standard deviation of weekly prices during the marketing year.

Estimated Information Program Benefits: The simulated changes in marketing margins due to actual week-to-week changes in shipping-point prices are shown in table 1. To estimate the benefits of the information program, we must estimate what the price variability would have been without the HAB information program. Our approach is to compare the variability of prices immediately before initiation of the information program with variability of prices after beginning the information program. A limitation of this approach is that the entire change in price variability is attributed to the information program, even if there were other factors contributing to more stable prices.

As noted, the standard deviation of annual California Hass avocado prices decreased from an annual average of 0.2843 during the five-year period 1998–2002 to an annual average of 0.2045 from 2003–2007. This decrease of 28% in price variability is used as the maximum reduction in price variability due to the HAB information program. The estimated total five-year increase in avocado marketing margins due to price variability from table 1 is $31,661,000. Thus, a reduction of 28% in margins would have been worth a five-year (undiscounted) total of $12.3 million. This savings is reflected in both lower retail prices paid by consumers and higher prices to growers at the shipping point.

HAB Information Program Costs: The annual costs of HAB information programs are listed by category in each HAB annual report and are summarized in table 2. Annual expenditures for the information programs ranged from $340,179 to $1,090,228 over the five years, with an average annual cost of just under $750,000. Total five-year costs for the categories of information, analysis, and the Network Marketing Center were in a rather tight range of $530,514 to $536,936. Almost 57% of total costs for the first five years ($2,125,915) were in the interaction category.

Table 2: Annual and Total Costs of HAB Information Programs by Cost Category, 2003–2007

	Year					
Cost Category	2003	2004	2005	2006	2007	Grand Total ($)
Information ($)	28,619	219,553	71,104	123,434	94,226	536,936
Analysis ($)	0	44,843	168,976	197,375	120,281	531,475
Interaction ($)	286,560	658,956	378,566	404,241	397,592	2,125,915
Network Marketing Center ($)	0	166,876	66,163	179,052	118,423	530,514
Total Information($)	340,179	1,090,228	684,809	904,102	730,522	3,749,840

Source: HAB Annual Reports, 2003–2007.

Allocation of Net Benefits: The division of the total benefit, as well as the assessment cost to fund the information program, between consumers and producers depends upon the value of consumers' price elasticity of demand, E_D, relative to producers' price elasticity of supply, E_S, of avocados to the U.S. market. The share of a change in margin going to consumers in terms of lower price is

$$\Delta P = \frac{E_S}{E_S - E_D}$$

Carman, Li and Sexton (2010) estimated demand relationships for avocados using various combinations of functional forms and variables. Estimates of the relationship between per capita quantity and real price were very stable regardless of the variables included. Using the estimated price coefficients, we evaluated E_D at the average of price and quantity for the past ten years. Regardless of the specific model estimated, we obtained a value of $E_D \approx -0.25$ during this ten-year period, meaning that a 4% increase in price would be associated with about a 1% decrease in consumption.

There are no recent studies of the price elasticity of supply for avocados. Supply functions are difficult to estimate empirically and the elasticity of supply varies by the length of run (time frame) under consideration—e.g., supply becomes more elastic (responsive to price) in the long run as productive inputs become variable to producers.

Supply analysis is particularly difficult for perennial crops because the analyst must normally specify a dynamic model containing equations for plantings, removals, bearing acreage as a function of plantings and removals, and yield. An alternative approach to studying the supply relationship is to estimate a range of plausible values for elasticity of supply. If conclusions are robust across the range of supply elasticity values chosen, there is little need to worry about choosing among the plausible alternative values.

In considering a range of plausible values for elasticity of supply, note that short-run supply of a perennial crop is highly inelastic because it is the product of bearing acreage and yield, neither of which is likely to be influenced much by current price. Thus, the supply of avocados from California is likely to be highly inelastic. The supply of imports to the United States emanating from Chile and Mexico, however, is apt to be more elastic because the total supply in each country can be allocated to domestic consumption or to various export markets. Thus, an increase in price in the United States due to factors such as successful promotions, is likely to cause Chilean and Mexican shippers to increase supply into the United States. Based on these considerations, we specified three alternative values for E_S: 0.5, 1.0, and 2.0.

Using $E_D = -0.25$ and values of E_S ranging from 0.5 to 1.0 to 2.0, we calculated the estimated consumer and producer shares of costs and benefits from the information program. Estimated consumer shares ranged from 67–89%, with producer shares ranging from 33–11%, depending upon the value assumed for E_S. Assuming that the entire margin reduction can be attributed to the HAB information program, the total net benefit is $12.3 million gross benefit minus $3.75 million program cost, or $8.55 million net benefit. Producers' share of this net benefit is then in the range of $0.94–$2.82 million dollars, with the remainder of the net benefit going to U.S. avocado consumers.

Concluding Comments

Publicly available market information has costs and benefits, but the costs of obtaining and disseminating information are typically much easier to estimate than the benefits or returns from having the information available to market participants. The present study attempts to measure the value of an information program designed to foster orderly marketing in the U.S. avocado market, with the value of information stemming from reduced price variability leading to reduced marketing margins. The HAB reported five-year information program expenditures of $3.75 million. Based on a 28% reduction in price variability, we estimated a five-year reduction in avocado marketing margins of $12.3 million, with net benefits totaling $8.55 million. With an inelastic demand at recent prices and quantities, the majority of estimated benefits flow to consumers, although producers still receive an attractive return for their share of expenditures.

Public market-information programs for agricultural commodities have been under pressure for several decades as a result of changing channels of distribution and decreased government funding. Terminal market price and arrival data have decreased as these markets have been by-passed by the movement to direct purchase programs by large-scale food retailers, and market reports have been reduced and suspended in response to government budget reductions.

In light of the significant consumer benefits estimated for the HAB information program, we believe that new and innovative market-information programs based on advanced information technology and rapidly evolving information delivery systems should be seriously considered for implementation.

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End of Life Vehicles and Air-Conditioning Refrigerant: Can Regulation Be Cost Effective?

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Vehicles that are no longer driven contribute to air pollution. HFC-134a is a common refrigerant in vehicle air-conditioning systems and a greenhouse gas. Increased regulation pertaining to the removal of HFC-134a from End-of-Life Vehicles has been proposed as a means to reduce air pollution. We estimate the amount of HFC-134a that remains in vehicles that are no longer driven in California and find that increased regulation is not warranted.

HFC-134a, the refrigerant used in the air-conditioning systems of vehicles beginning with the 1995 model year, is a toxic greenhouse gas. When released into the atmosphere, HFC-134a reacts with sunlight and creates ground level ozone that is detrimental to the health of humans and ecosystems. As vehicles are driven, small amounts of the refrigerant leak into the atmosphere. When a vehicle reaches the end of its drivable life, an unknown quantity of HFC-134a remains in its air-conditioning system, possibly to leak into the atmosphere, possibly to be recovered.

Vehicles that have reached the end of their drivable lives are commonly known as End-of-Life Vehicles or ELVs. ELVs have been issued either a junk title or salvage certificate by the Department of Motor Vehicles (DMV) and cannot legally be driven. ELVs are often sold to dismantlers or junkyards and used for parts or metal recycling.

The removal and recovery of HFC-134a from these End-of-Life Vehicles is regulated under sections 608 and 609 of the Clean Air Act, which prohibits the venting of vehicle refrigerant into the atmosphere. Section 608 and section 609 of the Clean Air Act require vehicle dismantlers to remove and recycle any vehicle refrigerant contained within End-of-Life Vehicles. These regulations, however, are rarely enforced.

The California Air Resources Board (CARB) has identified improving the recovery rate of HFC-134a from End-of-Life Vehicles as part of its greenhouse gas reduction strategy. However, little is known about the quantity of HFC-134a remaining in End-of-Life Vehicles found in licensed junkyards and dismantling yards. Nor is much known about the model years common in junkyards and, hence, about the percentage of ELVs that contain this specific refrigerant.

This report presents the preliminary results from an analysis for CARB that estimates the portion of the ELV population containing HFC-134a and that quantifies the amount of HFC-134a remaining in these vehicles. When combined, these two estimates help determine whether increased enforcement of sections 608 and 609 of the Clean Air Act is warranted.

Vehicle Sampling

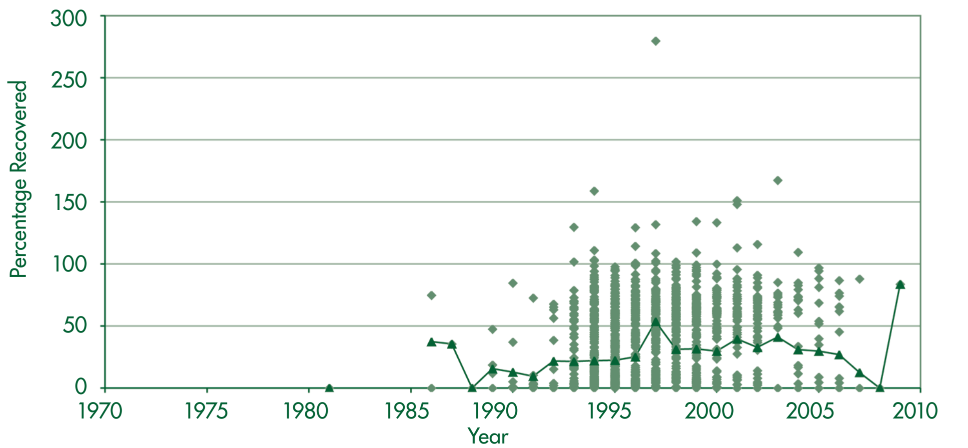
To quantify the amount of HFC-134a remaining in End-of-Life Vehicles, refrigerant samples were taken from 2,002 vehicles on dismantler lots throughout California in two rounds of sampling. An initial sample of 160 vehicles was conducted at one location in Antelope, California in January 2009; later, 1,842 vehicles were sampled at 29 dismantler locations throughout the state. The 30 participating vehicle dismantlers were all licensed by the State of California and were members of the State of California Auto Dismantlers Association.

The sampling was conducted by technicians certified in refrigerant handling and safety procedures from January through August 2009. The technicians entered dismantler lots and identified vehicles with enough spatial clearance to allow for sampling and refrigerant collection. In order to be sampled, a vehicle was required to have an operational front hood and a visible Vehicle Identification Number (VIN).

This sampling was not random, as the technician had to get permission from the dismantler owner before sampling and was often told which vehicles were "off-limits." At some dismantler lots, this restricted access meant only a handful of vehicles could be sampled. Once a vehicle's refrigerant was sampled, the refrigerant was returned to the vehicle and the vehicle was marked for refrigerant collection. As the amount of refrigerant was sampled, the technician recorded vehicle-specific information including refrigerant capacity, vehicle make, vehicle model year, license plate information, mileage, vehicle color, and the overall condition of the vehicle. At the end of each day of sampling, the refrigerant was collected from each sampled vehicle and was reclaimed by a licensed disposal service.

Sampled vehicles ranged in model year from 1970 to 2009, with a mean of 1997, and a standard deviation of three years. There were 1,536 vehicles, 77% of the sample, that were 1995 and newer model-year vehicles. Across this sample of 2,002 vehicles, 1,966 vehicles had air-conditioning systems utilizing HFC-134a. Identifying the specific refrigerant used in a vehicle's air-conditioning system prior

Figure 1: Model Year and Percentage of HFC-134a Recovered from Sampled End of Life Vehicles



to sampling was nearly impossible and 36 vehicles containing the precursor to HFC-134a, R-12, were sampled.

Across all sampled vehicles containing HFC-134a, an average of 27% of vehicle-specific refrigerant capacity remained in the air-conditioning system. However, the amount of HFC-134a remaining in the air-conditioning systems of sampled vehicles varied widely. No HFC-134a remained in the air-conditioning systems of 781 sampled vehicles. The other 1,185 sampled vehicles containing HFC-134a contained an average of 45% of vehicle-specific refrigerant capacity.

There was also very little correlation between the percentage of HFC-134a remaining in sampled vehicles and any geographic, dismantler, or vehicle-specific characteristics. Across the sample of vehicles containing HFC-134a, the percentage of refrigerant was correlated with model year and whether the vehicle had a license plate at the time of sampling. Vehicles with license plates tended to have a higher percentage of refrigerant remaining, holding all other variables constant. As the model year of a vehicle increased, or the vehicle decreased in age, the percentage of refrigerant remaining tended to increase, holding all other variables constant. Surprisingly, vehicle mileage, collision status, and a proxy for the number of days the vehicle had been on the dismantler lot were not significant in determining the amount of HFC-134a remaining in the air-conditioning system.

Figure 1 presents the percentage of recovered HFC-134a for each sampled End-of-Life Vehicle with the solid line representing the average. Seventeen of these End-of-Life Vehicle had over 100% of refrigerant capacity at the time of sampling. These abnormally large values could be the result of sampling errors or could be caused by incorrectly charged vehicle air-conditioning systems during the vehicle's lifetime.

California End-of-Life Vehicle Population

The California Department of Motor Vehicles (CA DMV) does not compile statistics pertaining to junk titles and salvage certificates. In fact, the CA DMV purges vehicles from their main database if they have a long lapse in registration activity, whether a vehicle has been junked or moved out of state. As no statistics were directly available regarding the End-of-Life Vehicle population, we had to reconstruct what had happened to vehicles and obtain information about ELVs using a two-step process. We first looked at annual CA DMV registration records from 2000 through 2008, and identified the cross section of vehicles with a registration status that had lapsed from one year to the next. From 2000 through 2008, nearly 40 million vehicles had a change in registration status. These vehicles represented the potential population of ELVs, and their unique Vehicle Identification Numbers (VINs) were submitted to CA DMV to obtain their full registration histories from some supplemental databases.

Among these 40 million VINs, 3,190,040 vehicles were issued a junk title or salvage certificate from January 1, 2005 through December 31, 2007. These vehicles constitute our End-of-Life Vehicle population. Some vehicles may be missing, yet these represent the most recent and most reliable estimate of all vehicles junked within California over a three-year period.

Among these 3,190,040 ELVs, the model year was normally distributed with a mean of 1991 and a standard deviation of seven years. Of the ELVs from 2005 through 2007, 32% were 1995 and newer model years. These statistics are substantially different from the model-year distribution of the vehicles sampled for their refrigerant. The population of End-of-Life Vehicles is much older than the sampled vehicles and a much smaller percentage would have contained HFC-134a.

Of course, the percentage of End-of-Life Vehicles that are 1995 and newer model years increases each year, as seen in Table 1. On average, the percentage of 1995 and newer ELVs reported to the CA DMV has increased 0.25% a month, or 3% a year. Extrapolating ahead, the amount of HFC-134a in ELVs and the potential for significant

Table 1: Portion of End of Life Vehicle Population Containing HFC-134a

Date	1995 and Newer Model Year ELVs
January 2000	9%
January 2005	24%
January 2006	27%
January 2007	29%
January 2015 (Projected)	50%
January 2023 (Projected)	99%

environmental damage will not be fully realized for many years to come.

We also analyzed End-of-Life Vehicles by the vehicle age at the time it was issued a junk title or salvage certificate. Each year from 2000 through 2007, the average age of an ELV has increased on average by two months. In 2000, the average age of an ELV was 14 years, 9 months; by 2007 the average End-of-Life Vehicle was 16 years, 2 months old. Thus, while the percentage of 1995 and newer model-year vehicles is increasing, the population of ELVs is also increasing in age.

The ELV population from 2005 through 2007 was owned by 1,629 vehicle dismantlers within California as well as 210 non-dismantling and out-of-state businesses. Table 2 outlines the breakdown of End-of-Life Vehicle ownership.

CARB and U.S. EPA only have jurisdiction over licensed vehicle dismantlers in California. Thus, the benefits of increased enforcement of section 608 of the Clean Air Act pertaining to the removal and disposal of HFC-134a will be limited to only those ELVs that are on licensed vehicle dismantler lots in California—79% of all ELVs from 2005 through 2007.

Table 2: Last Known Owner of End of Life Vehicles by Category

Category	Percentage of ELVs Owned	Number of Businesses
Licensed California Dismantler	79%	1,518
Non-Licensed California Dismantler	1%	111
Out-of-State and Non-Dismantler Businesses	15%	73
Private Individual and Unidentified Entities	5%	137

Results and Conclusions

In determining the benefit of efforts by CARB to support U.S. EPA's regulations governing the removal of HFC-134a, we estimated the average amount of HFC-134a remaining in End-of-Life Vehicles and extrapolated this finding to all vehicles in the ELV fleet that contained HFC-134a. We have focused on the time frame 2005 through 2007, as this period represents the most recent and most accurate information available from CA DMV. From 2005 through 2007, there were 1,020,938 1995 and newer model-year ELVs—an average of 340,313 a year. Assuming the sample average of 220 grams of recovered refrigerant, an average of 74,869 kg of HFC-134a was left in the air-conditioning systems of vehicles on California dismantler lots each year.

Assuming the conditions from 2005 through 2007 persist, the portion of ELVs containing HFC-134a will continue to increase by approximately 3% a year and the average age of End-of-Life Vehicles will increase approximately two months a year. This translates to an increase of 54,203 ELVs containing HFC-134a from 2008 through 2012. Assuming the mean HFC-134a recovered from each ELV remains at 220 grams through 2012, we project that an additional 10,949 kg of HFC-134a will remain in the ELV population. Thus, while approximately 74,869 kg of HFC-134a remained in vehicles on California dismantler lots each year from 2005 through 2007, by 2012 it will increase to 86,793 kg.

There are large variations in the amount of HFC-134a remaining in ELVs, as well as the portion of the fleet that contains the refrigerant. This variation is due to large differences among vehicles in the rate of dissipation of HFC-134a, as well as the ever-changing profile of the ELV population. The potential benefit to any actions by the California Air Resources Board to enforce sections 608 and 609 of the Clean Air Act will be affected by this variance. In addition, any benefit of increased enforcement will be restricted to the 79% of ELVs that were on licensed dismantler lots in California. Thus, while 74,869 kg of HFC-134a remained on vehicle dismantler lots in California from 2005 through 2007, only 59,146 kg was on licensed vehicle dismantler lots. The presence of unlicensed dismantlers reduces the potential benefit of any efforts by the California Air Resources Board now and into the future to enforce regulations on HFC-134a.

Given the wide range of refrigerant that was recovered from sampled vehicles, along with the inability to identify the specific refrigerant within a vehicle's air-conditioning system, enforcing the removal of HFC-134a from End-of-Life Vehicles would be extremely difficult and expensive. From 2005 through 2007, only one out of every three End-of-Life Vehicles contained HFC-134a and 40% of those vehicles had no HFC-134a remaining in their air-conditioning systems. Only 220 grams of HFC-134a, 26% of capacity, was recovered from sampled End-of-Life Vehicles, which suggests that increased regulation would most likely not be cost effective.

Further research into the leakage of HFC-134a during a vehicle's drivable life, or increased enforcement of vehicle dismantling licensing, may present better options for decreasing the release of such a harmful greenhouse gas into the atmosphere. While sections 608 and 609 of the Clean Air Act were necessary in order to present guidelines to vehicle dismantlers regarding the handling of HFC-134a, their enforcement may be counterproductive at this time. The complexity of the vehicle lifecycle and the factors influencing the dissipation of HFC-134a into the atmosphere may be too complex for the regulations as they currently exist.

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