Considering Trade Policies for Liquid Biofuels

May 2007

Masami Kojima, Donald Mitchell, and William Ward

Energy Sector Management Assistance Program (ESMAP)

Produced in India
First printing June 2007

ESMAP Reports are published to communicate the results of ESMAP's work to the development community with the least possible delay. The typescript of the paper therefore has not been prepared in accordance with the procedures appropriate to formal documents. Some sources cited in this paper may be informal documents that are not readily available.

Contents

List of Tables:

List of Figures:

Acknowledgments

This study was undertaken under the guidance of the Energy and Mining, Agriculture and Rural Development, and Environment Sector Boards of the World Bank, with support from the Energy Sector Management Assistance Program (ESMAP), a joint program of the United Nations Development Program and the World Bank. The financial assistance of the Government of the Netherlands through ESMAP is gratefully acknowledged.

This report was prepared by Masami Kojima of the Oil, Gas, and Mining Policy Division, World Bank; Donald Mitchell of the Development Prospects Group, Development Economics, World Bank; and William A. Ward, Professor and Director, Center for International Trade, Clemson University. The authors thank Derek Byerlee of the World Development Report, Development Economics and John Nash of the Sustainable Development Department, the Latin America and the Caribbean Region, both of the World Bank, for providing comments as peer reviewers. Additional comments from Boris Utria of the Sustainable Development Department of the Africa Region; Carlos Braga and Krista Lucenti of the International Trade Department; Ariel Dinar, Gershon Feder, Daniel Lederman, and William Martin of the Development Research Group, Development Economics; Richard Henry of the Agribusiness Department of the International Finance Corporation; and Dina Umali-Deininger and Kseniya Lvovsky of the Sustainable Development Department of the South Asia Region; all of the World Bank Group, are gratefully acknowledged.

The authors are also grateful for comments provided by the following external reviewers:

- Ronald Steenblik, Research Director, Global Subsidies Initiative
- James Fry, Managing Director, LMC International
- Dirk Aßmann, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
- Melinda Kimble, Senior Vice President, UN Foundation; and the three commentators who submitted comments through the UN Foundation—Lester B. Lave, University Professor and Higgins Professor of Economics; Seth A. Blumsack, postdoctoral research fellow, Carnegie Mellon Electricity Industry Center; and W. Michael Griffin, Executive Director, Green Design Institute; all of Tepper School of Business, Carnegie Mellon University
- Astrid Agostini, Gustavo Best, Merritt Cluff, Jamie Morrison, and Jennifer Nyberg of the Food and Agriculture Organization (FAO).

Editorial support was provided by Jenepher Moseley, and the publication and distribution of the report was managed by Marjorie K. Araya of ESMAP.

Abbreviations and Acronyms

ACP	Africa, Caribbean, and Pacific
AMS	Aggregate Measure of Support
APEC	Asia-Pacific Economic Cooperation
ASTM	American Society of Testing and Materials
CAFTA	Central American Free Trade Agreement
CAP	Common Agricultural Policy
CBI	Caribbean Basin Initiative
CBO	Congressional Budget Office
CCC	Commodity Credit Corporation
CCP	Counter-cyclical payments
CIF	Cost, insurance, and freight
CO_2	Carbon dioxide
CRS	Congressional Research Service
EBA	Everything But Arms
EIA	Energy Information Administration
EPPO	Energy Planning and Policy Office
ETBE	Ethyl tertiary-butyl ether
EU	European Union
FAO	Food and Agriculture Organization
FAPRI	Food and Agricultural Policy Research Institute
FOB	Free on board
GATT	General Agreement on Tariffs and Trade
GDP	Gross domestic product
GHG	Greenhouse gas
GSP+	Generalized System of Preferences Plus
HS	Harmonized System
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IEA	International Energy Agency
IISD	International Institute for Sustainable Development
IPC	International Food & Agricultural Tade Policy Council
MFN	Most favored nation
MTBE	Methyl tertiary-butyl ether
NAFTA	North American Free Trade Agreement
NBD	National Biodiesel Board
NExBTL	Next generation biomass to liquids
OECD	Organization for Economic Cooperation and Development
R&D	Research and development
RFA	Renewable Fuels Association
RON	Research octane number
RSPO	Roundtable on Sustainable Palm Oil
TIC	Tariff Information Center
TRQ	Tariff rate quota
UNCTAD	United Nations Conference on Trade and Development
USDA	U.S. Department of Agriculture

U.S. EIA	U.S. Energy Information Administration
U.S. EPA	U.S. Environmental Protection Agency
USITC	U.S. International Trade Commission
VEETC	Volumetric Ethanol Excise Tax Credit
WCO	World Customs Organization
WTO	World Trade Organization

Units of Measure

A$	Australian dollar
C$	Canadian dollar
ºC	Degrees Celsius
€	Euro
kg	Kilogram
R$	Brazilian real
Rs	Rupees
SKr	Swedish kroner

Note: For current costs and prices, exchange rates prevailing in April 2007 are used. For past costs and prices, the exchange rate prevailing at the time is used.

Glossary of Terms

Amber box Amber box policies in the Uruguay Round Agreement on Agriculture are subject to careful review and reduction over time. Amber box policies include policies such as market price support, direct payments, and input subsidies.

Agreement on Agriculture Part of the Uruguay Round Agreement covering issues related to agriculture. Three pillars of this agreement are market access, export subsidies, and domestic subsidies.

Anhydrous ethanol Ethanol with sufficient water removed to make it suitable for blending with gasoline.

Biodiesel A diesel fuel, primarily alkyl (methyl or ethyl) esters (an organic compound with two oxygen atoms), that can be used in blends or in neat (pure) form in compression-ignition engines and produced from a range of biomass-derived feedstocks such as oilseeds, waste vegetable oils, cooking oil, animal fats, and trap grease.

Biomass Organic matter available on a renewable basis. Biomass includes all plants and their residues: forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, and fast-growing trees and plants.

Blue box Blue box policies in the Uruguay Round Agreement on Agriculture are exempt from reduction commitments. Examples include program payments received under production limiting programs—if they are based on fixed area and yields, a fixed number of head of livestock, or if they are made on 85 percent or less of base level of production.

B5, B20 Diesel-biodiesel blends containing, respectively, 5 percent and 20 percent biodiesel.

Cellulosic ethanol Ethanol produced from cellulose, which includes a great variety of biomass such as forestry materials, agricultural residues, energy crops such as switch grass, and urban wastes.

Denatured ethanol Ethanol that has been rendered toxic or undrinkable, for example by addition of gasoline.

E5, E10, E85 Ethanol-gasoline blends containing, respectively, 5 percent, 10 percent, and 85 percent anhydrous ethanol.

Green box The green box describes domestic support policies that are not subject to reduction commitments under the Uruguay Round Agreement on Agriculture. These policies are assumed to affect trade minimally, and include support such as research, extension, food security stocks, disaster payments, and structural adjustment programs.

HS A commonly used abbreviation for the Harmonized Commodity Description and Coding System of the World Customs Organization, which uses a numbering system to designate commodities.

Hydrous ethanol Ethanol with about 95 percent purity, the balance being water. It is not suitable for blending with gasoline.

Most favored nation (MFN) status	An agreement between countries to extend the same trading privileges to each other that they extend to any other country. MFN treatment is granted if two countries are members of the WTO, or if MFN is specified in an agreement between them.
Palm olein	The liquid fraction obtained by fractionation of palm oil after crystallization at controlled temperatures.
Tariff rate quota	A two-tier tariff where the tariff rate charged depends on the volume of imports. An in-quota tariff is charged on imports within the quota volume. A higher (over-quota) tariff is charged on imports in excess of the quota volume.
Undenatured ethanol	Pure ethanol without foreign materials intentionally added.

Executive Summary

1 This report—which addresses the issues associated with trade in liquid biofuels—is a second ESMAP report on biofuels, and forms part of a broader assessment of bioenergy undertaken by the World Bank. The report asks how liberalizing trade in liquid biofuels might affect biofuel production and consumption.

2 Bioenergy is playing an increasingly important role as an alternative and renewable source of energy. Bioenergy includes solid biomass, biogas, and liquid biofuels. Combustion of biomass residues for heat and power generation is commercially viable without government support in some applications. Liquid biofuels made from biomass are attracting growing interest worldwide, driven by concerns about energy security, climate change and local environmental considerations, and a desire to support domestic agriculture. The global liquid biofuel market today utilizes so-called first-generation technologies and relies mainly on agricultural food or feed crops for feedstock. Second-generation biofuels, still far from commercially viable, can open up many new opportunities because they can be sourced from a much wider variety of feedstocks, vastly expanding the potential for fuel production and for abating greenhouse gas emission. The timing of commercialization is uncertain, although some industry analysts indicate that the needed cost reductions may be achieved in the coming decade.

3 The two most important liquid biofuels today are ethanol and biodiesel, and they are of primary interest for transportation. Support policies for these two biofuels fall into two general categories: (1) policies to replace consumption of petroleum fuels through such programs as mandating of biofuel use and comparative reductions in fuel tax for biofuel; and (2) policies to stimulate biofuel production domestically; examples of such policies include producer subsidies; import tariffs to protect local producers and to direct government support given to all biofuels to local production; and research to develop new or improved technologies. Some policies reduce trade directly and are obvious subjects of this report. Other policies do not reduce trade directly but may have indirect distorting effects on trade.

4 Focusing primarily on ethanol and biodiesel, the report takes a time horizon of the next five to ten years. It outlines the important link between agriculture and biofuels, reviews past and present government policies for agriculture and for biofuels, and considers how these policies might affect the world biofuel market. The report highlights the links among the markets for oil, biofuels, feedstocks, and the byproducts of biofuel processing. It reviews existing studies examining the likely consequences of much larger biofuel production and trade liberalization on biofuels and their feedstocks. It concludes with policy considerations.

5 Current commercial feedstocks for biofuels are predominantly agricultural crops. Ethanol is made from sugar cane, sugar beets, maize, wheat, cassava, and other starches. Biodiesel is produced from rapeseed oil, soybean oil, waste oil, and, increasingly, palm oil. The physical properties of biodiesel depend on the feedstock and the extent of further downstream processing. Biodiesel manufactured using traditional

methods (reacting an oil with an alcohol) can have cold-climate and other performance problems. The world's leading ethanol producers are Brazil (from sugar cane) and the United States (from maize). The world's leading biodiesel producer is Germany (from rapeseed oil). Because biodiesel has historically been more costly than ethanol, the biodiesel market is much smaller. A number of industrial and developing countries have instituted programs to promote biofuel production and consumption, setting targets—some mandatory—for increasing the contribution of biofuels to their transport fuel supplies. In the future, second-generation biofuels could use agricultural residues and other feedstocks that are not used as food or feed.

6 Feedstock costs comprise more than half the costs of producing both ethanol and biodiesel. Despite remarkable reductions in production costs over the years in Brazil, the United States, and elsewhere, biofuels to date have been marginally economic under favorable conditions (high world oil prices and low feedstock prices) and only in a handful of circumstances—such as Brazil in 2004 and 2005. More generally, however, biofuels have not been commercially viable without significant government support. This is despite the fact that Brazil and the United States, the two leading producers of biofuels, are among the most efficient producers of biofuel feedstocks. As a result, all biofuel markets have been supported by government protection policies. Trade in biofuels is limited, although it is growing.

7 Direct and indirect policy-induced price distortions play important roles in the financial attractiveness of ethanol and biodiesel production and trade. The resulting price distortions are large, and the forward and backward links with other price-distorted markets (for example, sugar) are strong. Any effect on feedstock prices arising from agricultural or biofuel policies has an immediate effect upon the economics of biofuel production. Agricultural policies in industrial countries have tended to depress crop prices internationally, making, for example, ethanol from sugar cane, more attractive in financial terms than in economic terms. Complicating the analysis further, the major feedstocks have primary uses as human foods and animal feed; in addition, biofuel manufacture produces byproducts that play important roles in biofuel economics. Increasing diversion of a crop to the biofuel market has also been observed to link that crop's price to the world petroleum market. These observations suggest that policy analysis should use economic values rather than relying only on financial or commercial prices, and also that the economic analysis needs to consider multiple markets in which many related prices are distorted by domestic and foreign government policies.

8 Impediments to biofuel trade include high import tariffs, largely on ethanol, and technical barriers to trade. The latter may be legitimate and even welfare-enhancing, but reduce the volume of trade. Arguably the greatest technical barrier in the coming years could be certification of biofuels for environmental sustainability, prompted by concerns about burning and clearing of rainforests to plant palm and soybeans (both feedstocks for biodiesel) in Southeast Asia and Latin America.

9 If policies that are potentially market-distorting but not trade-distorting—such as consumption mandates and fuel excise tax reductions for all biofuels—are maintained, liberalizing biofuel trade is likely to increase demand for biofuels by reducing prices in previously protected markets. Massive growth of biofuel production

based on current technologies, however, would face several challenges: limits on the amount of unutilized land that can be brought into production economically and potential water shortages that may contain expansion. Efficient producers of biofuels with scope for expansion (such as Brazil) will benefit, whereas those currently enjoying preferential treatment (such as the Caribbean countries) will lose their trading opportunities. An immediate effect of trade liberalization is estimated to be an increase in feedstock prices and a fall in byproduct prices on the world market. More generally, biofuel and agricultural trade liberalization is expected to increase world prices of agricultural commodities. Higher feedstock prices in turn could slow down the growth of the global biofuel market. Biofuel production growth has already begun to change the price relationships among various agricultural commodities. With a greater share of maize and other markets characterized by inelastic demand (through biofuel mandates, among others), increased price variability and market volatility are expected.

10 Higher food prices will benefit producers and harm consumers. Net sellers of food, including many of the poor engaged in agriculture in developing countries, will benefit. The welfare of urban workers and net buyers of food generally will decline. Despite being producers of agricultural crops, most evidence suggests that poor farming households in rural areas are net buyers of food. Because maize is the staple food in a number of developing countries, rapidly rising maize prices are a particular concern. Prices are expected to rise more steeply for the food products that developing countries import than for the commodities they export. The poorest countries, very few of whom export products on which there are currently high tariffs, would generally be worse off. Lowering tariffs in developing countries could partially mitigate these adverse effects by lowering prices of imported food items and by creating opportunities for regional trade. One possible exception to the above price trend is oilseeds and oilseed products, on which some major oilseed producers assess export taxes. Removal of the export taxes may prompt a large supply response and a fall in world prices, and greater exports of biodiesel feedstocks, rather than biodiesel, to industrial countries.

11 Biofuel trade liberalization would increase competition, which should in turn help improve efficiency, bring down costs, and enable the world's most efficient producers to expand their market share. Removal of high tariffs would bring down prices in highly protected markets, although world biofuel prices may rise. That said, removing border restrictions for biofuels coupled with continued agricultural and biofuel policies that distort biofuel markets could prolong those distortions, as additional markets for subsidized agricultural outputs and biofuels would be created. The greatest welfare gains might be realized with the full range of trade reforms carried out simultaneously. Failing that, trade in ethanol and biodiesel might be liberalized as a first step. Such a move could also force governments to address openly the question (and the costs) of what objectives their biofuel support policies are actually pursuing.

Report Summary

1 Bioenergy is playing an increasingly important role as alternative and renewable source of energy. Bioenergy includes solid biomass, biogas, and liquid biofuels. Combustion of biomass residues for heat and power generation is commercially viable without government support in some applications. Liquid biofuels made from biomass are attracting growing interest worldwide. The global liquid biofuel market today utilizes so-called first generation technologies and relies mainly on agricultural crops for feedstock. Second-generation biofuels, still far from commercially viable, can open up many new opportunities because they can be sourced from a much wider variety of feedstocks, vastly expanding the potential for fuel production and for abating greenhouse gas (GHG) emission. The timing of commercialization is uncertain, although there are indications that the needed cost reductions may be achieved in the coming decade.

2 This report—which focuses on the issues associated with trade in liquid biofuels—is a second ESMAP report on biofuels, and forms a part of a broader assessment of bioenergy undertaken by the World Bank. The growing interest in liquid biofuels is driven principally by three factors:

- Concerns about energy security[1]
- Environmental considerations that focus upon GHG emissions, primarily in industrial countries, and on tailpipe emissions in developing countries that have relatively lenient vehicle emission and fuel quality standards
- A desire to support and protect domestic agriculture against the backdrop of negotiations for agricultural trade liberalization in international organizations and treaties.

3 The two most important liquid biofuels today are ethanol and biodiesel, and they are of primary interest for transportation. Support policies for these two biofuels fall into two general categories: (1) policies to replace consumption of petroleum fuels with such programs as mandated biofuel use and comparative reductions in fuel tax for biofuel; and (2) policies to stimulate biofuel production domestically; examples of such policies include producer subsidies; import tariffs both to protect local producers and to direct to local production government support that is now given to all biofuels; and research to develop new or improved technologies. Some policies distort trade directly[2]

[1] With energy as with food, important policy distinctions are made between *security* and *self-sufficiency*. See footnote 15 of Chapter 2.

[2] Anything that subsidizes or mandates—and thereby increases—consumption of a product generates new trade, everything else being equal, and in that sense all government support is trade-distorting. But the tradition has been to call a policy "trade distorting" if it has an anti-trade bias or reduces trading opportunities for others in the global trading system (such as domestic subsidies benefiting only domestic production, import tariffs and other import restrictions, export subsidies, and export taxes). This report uses the phrase "non-trade distorting" to describe policies that do not create an anti-trade bias or reduce global trading opportunities for some.

and, thus, are obvious subjects of this report. Other policies do not distort trade directly but may affect it indirectly.

4 The previous ESMAP report on biofuels (ESMAP 2005) found the economics of biofuel production and consumption to be site- and situation-specific, suggesting scope for welfare gains from specialization and trade. This report asks how liberalizing trade in liquid biofuels might affect biofuel production and consumption. The report focuses on ethanol and biodiesel over a time horizon of the next five to ten years. The report does not attempt to assess the effect of policy changes on emerging technologies or new (not yet commercially proven) feedstocks, such as cellulosic ethanol; this is because these are unlikely to become sufficiently competitive commercially within a decade to have a significant impact on international trade in biofuels. The report also does not cover direct use of plant oils in engines because of their limited application. Nor does the report consider specific environmental effects of trade liberalization. The report begins by outlining the important link between agriculture and biofuels. It then covers past and present government policies for both agriculture and biofuels, and considers how these policies might affect the world biofuel market. The report highlights the links among the markets for oil, biofuels, feedstocks, and the byproducts of biofuel processing before reviewing existing studies, examining the likely consequences of much larger biofuel production and of trade liberalization. It concludes with policy considerations for liberalizing trade in biofuels.

5 Current commercial feedstocks for ethanol are sugar cane, sugar beets, maize, wheat, cassava, and other starches; in the future, cellulosic ethanol made from energy crops, forest and agricultural residues, and municipal solid waste could open up opportunities around the world, including those countries that are not suited for ethanol production today. Biodiesel is produced from rapeseed oil, soybean oil, waste oil, and, increasingly, palm oil. Second-generation biofuels based on thermochemical processes can use virtually all forms of biomass to make diesel, gasoline, and ethanol.

6 Ethanol is a chemical compound, but biodiesel is a mixture of many compounds and its physical properties vary. Depending on the feedstock and the extent of further downstream processing, biodiesel manufactured using traditional methods (reacting an oil with an alcohol) can have cold-climate and other performance problems, making biodiesel more suitable for use in low-percentage blends. The world's leading ethanol producers and their primary feedstocks are Brazil (from sugar cane) and the United States (from maize). The two countries also dominate sugar and maize exports, respectively. The world's leading biodiesel producer is Germany (from rapeseed oil). Because biodiesel has historically been more costly than ethanol, the biodiesel market is an order of magnitude smaller. A number of other countries have instituted programs to promote biofuel production and consumption. Argentina, Australia, Canada, Colombia, EU member states, India, Indonesia, Malaysia, New Zealand, People's Republic of China, the Philippines, and Thailand have all adopted targets—some mandatory—for increasing the contribution of biofuels to their transport fuel supplies.

7 Feedstocks typically account for more than half of the production costs of liquid biofuels. Despite remarkable reductions in production costs over the years in Brazil, the United States, and elsewhere, biofuels to date have been only marginally economic

under favorable conditions (high world oil prices and low feedstock prices) and only in a handful of circumstances, as in Brazil in 2004 and 2005. More generally, biofuels have not been commercially viable without significant government support. This is despite the fact that Brazil is the world's lowest-cost producer of sugar cane and the United States is among the lowest-cost producers of maize (net of subsidies)—that is, despite these two leading biofuel markets being two of the most efficient producers of biofuel feedstocks. As a result, all biofuel markets have been supported by government protection policies. Only about one-tenth of biofuels produced and sold are internationally traded, and Brazil accounts for about half of the exports. There is little trade of biodiesel, although it is growing.

8 Direct and indirect policy-induced price distortions play important roles in the financial attractiveness of ethanol and biodiesel production and trade. The resulting price distortions are large, and the forward and backward links with other price-distorted markets are strong. This suggests that policy analysis should use *economic* values rather than relying only on financial or market prices, and that the economic analysis needs to approximate general equilibrium considerations across multiple markets in which many related prices are distorted by domestic and foreign government policies. A corollary is that financial price relationships for biofuels generally should be viewed with some skepticism and that, for policy purposes, attention should be paid to economic values in which the distortions have been accounted for. A framework for economic analysis is detailed in the previous publication (ESMAP 2005).

9 It is worth noting that there are other applications of bioenergy—notably combustion of solid biomass for heat and power generation—that are commercially viable without government subsidies. However, there exists a growing tendency to focus on liquid biofuels, and some have even come to use the word "bioenergy" to mean bioethanol and biodiesel. Against this trend, it is important to view the potential of liquid biofuels in a broader context that encompasses all forms of biomass as energy sources.

Link Between Agriculture and Biofuels

10 Because feedstocks dominate the production costs of liquid biofuels, biofuels are closely linked to agriculture. Although ethanol from sugar cane in Brazil was the least-cost ethanol globally in much of the early 2000s, the economics became considerably more unfavorable following a surge in world sugar prices to 25-year highs in early 2006. Similarly, although ethanol from maize in the United States is generally more costly to produce than ethanol from sugar cane in Brazil, it was markedly cheaper in June 2000 when sugar prices in Brazil reached their peak while U.S. maize prices fell.

11 Agricultural policies affect the production, trade, and prices of agricultural commodities and thus are important determinants of biofuel feedstock costs and biofuel prices. Policies that distort agricultural trade are much more pervasive and substantial than trade-distorting policies in other goods such as manufactures. Historically, agricultural policies have tended to protect producers in industrial countries from imports from lower-cost producers while policies in developing countries have tended to tax producers. Some major oilseed producing countries continue to assess high export taxes on oilseeds and oilseed products; Argentina, for example, levies a 27.5 percent export tax

on soybeans and a 24 percent tax on soybean oil. Biofuels are assessed low or no export taxes. This export tax structure provides incentives to export biofuels rather than feedstocks. The highest protection is found in high-income Asia, Europe, and the United States. The European Union has used high tariffs to limit agricultural imports for most of the past 40 years, but is now shifting to direct payments that are decoupled from production decisions. The United States uses production subsidies and direct payments to agricultural producers. Although its overall support to agriculture is much smaller than that in high-income countries, Brazil provides low-interest loans to encourage expansion of agricultural exports and production. The value of total support to producers in the countries belonging to the Organization for Economic Development and Cooperation (OECD) was estimated at US$280 billion in 2005, compared to total value of agricultural production (at farm gate) of $837 billion in 2005 (OECD 2006b).

12 In countries where government provides support to agriculture, biofuel feedstocks are usually beneficiaries of the subsidies. Among major biofuel producers, maize and soybeans in the United States and sugar beets and rapeseed oil in the European Union are large recipients of government aid. The global sugar market is among the most distorted, with high protection and price supports to EU, U.S., and Japanese producers. These policies have been estimated to depress world sugar prices by up to 40 percent from the levels that would have prevailed under a free market (Mitchell 2004). Of all the biofuel feedstocks currently being used commercially, world sugar prices are expected to appreciate the most upon trade liberalization, adversely affecting ethanol economics.

Biofuel Policies

13 Among the support policies for biofuels that do not in themselves distort trade are biofuel mandates (for example, mandatory blending) and fuel tax reductions that do not distinguish between domestic and imported biofuels. Others—such as import tariffs and producer subsidies—clearly protect or subsidize domestic production at the expense of foreign-produced biofuels.

14 Fuel-tax reductions are the most widely used of all the support measures for biofuels, and are used even in Brazil to this day. This instrument depends on the magnitude of excise taxes levied on petroleum fuels. Unlike industrial countries, many developing countries levy low taxes or even subsidize petroleum fuels. Countries with low or negative taxes on petroleum fuels would find it difficult to launch commercially viable biofuel markets because biofuels have historically required large tax reductions to compete with petroleum fuels. Tax reductions for ethanol in EU countries have been as high as US$0.84 per liter, which are possible only because fuel taxes are high to begin with. The U.S. federal tax credit for ethanol is relatively “low” at US$0.135 per liter of ethanol blended, but a number of state governments offer additional tax reductions. Biodiesel has enjoyed comparable tax reductions, up to US$0.60 per liter of biodiesel blended in the European Union, US$0.28 per liter in Australia, and US$0.26 per liter in the United States. Among developing countries, Thailand provides significant fuel tax and fee reductions, as much as US$0.65 per liter in April 2006. In assessing these fuel tax reductions, it is important to bear in mind that fuel economy penalties associated with biofuel use amount to some 20–30 percent for ethanol and 5–10 percent for biodiesel,

which make the tax reductions per liter of petroleum fuel equivalent even larger than the stated rates per liter of biofuel.

15 Some tax differentials may be justified to account for externalities that are not properly reflected in end-user prices, environmental externalities being one such example. Carbon market payments can serve as an imperfect proxy for the benefits of reducing GHG emissions. But even if 100 percent of the lifecycle GHG emissions of petroleum fuels are assumed to be offset by biofuels, a carbon dioxide equivalent price range for the foreseeable future of between US$8 and US$20 per tonne would give a benefit of only $0.01–0.07 per liter of biofuel (the upper end of the range for biodiesel). For U.S. ethanol made from maize, only one-fifth to one-third of petroleum GHG emissions have been estimated to be offset by biofuels use even under favorable circumstances, making the environmental benefits markedly smaller. For local air-pollution benefits, one set of rudimentary calculations for developing countries suggests that the incremental value of ethanol compared with gasoline may not be much higher than $0.02 per liter, and $0.08 for biodiesel (ESMAP 2005). These externality estimates are much smaller than the tax reductions currently given to biofuels. Biofuel feedstock production and biofuel processing may also carry environmental costs: water and air pollution, soil depletion, and habitat loss and potentially very large GHG emissions associated with the conversion of forests and grasslands to cropland.

16 Fuel-tax reductions are typically granted to domestic and imported biofuels alike, in order to comply with World Trade Organization (WTO) principles that prohibit adjusting internal taxes and other internal charges to afford protection to domestic products. However, in the case of ethanol these tax reductions are often offset by nearly equivalent import tariffs to prevent foreign producers from sharing in the tax reductions provided to domestic consumers. Border protection through high tariffs and quota restrictions is a fiscally cheap way of protecting domestic producers and is liberally used by governments. Ethanol enjoys much higher tariff rates than biodiesel. The European Union levies a specific import duty of €0.192 (US$0.26) per liter is levied on undenatured ethanol and €0.102 (US$0.14) per liter on denatured ethanol; nevertheless, 101 developing countries enjoy duty-free access to the EU ethanol market. The United States levies a specific tariff of US$0.1427 per liter of ethanol in addition to a small ad valorem tariff. Some countries in the region enjoy various forms of duty-free access to the United States, and others take advantage of the “duty drawback” regulation. Australia has a specific import tariff of A$0.38143 (US$0.31) per liter for both ethanol and biodiesel. Even Brazil levies a 20 percent ad valorem import tariff on ethanol, although it was lifted temporarily in February 2006 in the face of a looming ethanol shortage. Tariff rates on biodiesel in industrial countries are typically low (Australia and Canada being two exceptions). Ethanol is classified as an agricultural good and biodiesel as industrial. Ethanol’s agricultural classification affords countries that impose high tariff rates on ethanol more time to liberalize ethanol trade, protecting domestic producers longer.

17 There are also technical barriers to trade. They may be legitimate and even welfare-enhancing, but reduce the volume of trade. Arguably the greatest technical barrier in the coming years could be certification of biofuels for environmental

sustainability, prompted by concerns about burning and clearing of rainforests to plant palm and soybeans (both feedstocks for biodiesel) in Southeast Asia and Latin America.

18 One form of government support given to biofuels seems appropriate. A legitimate role of government is to fund research and development (R&D) for activities that, because of their public good characteristics, are more likely to be undertaken if centrally financed. Although the private sector can and should be encouraged to undertake such work, R&D on biofuel technologies that can dramatically expand supply or reduce costs seems an appropriate area for governments to support. In developing countries, R&D could focus on technologies—for primary feedstock production, processing of biofuels, or equipment modifications for alternative uses (such as direct use of plant oils in stationary sources in remote areas with no electricity supply)—that are particularly suitable in their context. Studies of government subsidies for biofuels in industrial countries suggest that only a very small fraction of the aggregate subsidy is directed at R&D at present.

Impact of Higher Biofuel Production

19 For biofuel trade to become significantly larger, much greater global production of biofuels would be needed. The net effect of increased production of biofuels on a large scale will be higher food prices, which will benefit producers and harm consumers. The effects will be different both within countries and across countries. Within a given country, the welfare of urban workers will decline, but that of rural households, including farmers, will not necessarily rise uniformly. Despite being producers of agricultural crops, most evidence suggests that poor farming households in rural areas are net buyers of food. Because maize is the staple food in a number of developing countries, rapidly rising maize prices are a particular concern.

20 Higher feedstock prices in turn could slow down the growth of the global biofuel market. Growth in biofuel production has already begun to change the price relationships among various agricultural commodities. With a greater share of maize and other markets characterized by inelastic demand (through biofuel mandates, among others) that is also tied to the world oil market, and much smaller stocks of maize, soybeans, and other biofuel feedstocks, increased agricultural crop price variability and market volatility are expected.

21 The price correlation occurs not only between oil, biofuels, and their feedstocks, but also with other crops that are substitutes and with the byproducts of those crops. Agricultural commodity prices are highly correlated because most cropland can be used to produce several different commodities, many commodities are substitutes in consumption, and agricultural commodities are internationally tradable. Consumers also substitute among commodities in response to prices directly and indirectly. And increased production of biofuel byproducts—such as oil meals and distillers grains, which are used as high-protein animal feed, and glycerine, which is used in pharmaceutical and personal care products—lower their prices and influence the production of not only biofuel feedstocks themselves but other crops that produce similar byproducts.

22 Ramping up biofuel production will affect different farmers differently. A study of biodiesel found large differences in farmers' income between biodiesel

production from soybean oil and from palm oil. Soybeans yield nearly 80 percent by weight of soy meal, against 10 percent meal from palm. As a result, substantially higher soybean production for biodiesel would lead to a large surplus of meal and a large negative effect on soy meal prices, thereby reducing income to soybean farmers relative to that of palm growers (LMC International 2003).

23 By the same token, ramped-up biofuel production would have a major impact on land use and ecosystems. Another study modeled various scenarios aiming to blend 5 percent biofuels in gasoline and diesel worldwide by 2015 using agricultural crops. In terms of land requirements, the most efficient was to derive the incremental ethanol supply from sugar cane in the Center-South region of Brazil and biodiesel from palm oil. The land requirement for ethanol tripled if the incremental supply was produced from 50 percent cane and 50 percent maize from around the world. The land requirement for biodiesel quintupled if global use of other vegetable oils was made. In all cases, the amounts of additional land required were substantial. If the new biofuel feedstock production areas were shared proportionally among all carbohydrates and oilseeds, the world would need an increase of more than 15 percent, or roughly 100 million hectares (LMC International 2006). Because this study did not take water requirements into account, the actual incremental land required may be even greater.

Petroleum Price Impacts

24 Increasing biofuel production from a particular crop could also link that crop's prices to petroleum fuel prices. For the foreseeable future, biofuel production will remain small relative to petroleum fuel production and biofuels largely will continue to be price takers rather than drivers of transportation fuel prices. One study suggests a threshold level of diversion of a given crop to the biofuel market of about 10 percent. Above that level, any further diversion may link the price movement of that crop to the world petroleum market (LMC International 2006). Thus, large-scale production of biofuel would not protect consumers against high petroleum prices for long, because feedstock prices will rise and reduce the price gap between petroleum and biofuel. As such, biofuels are unlikely to become the "answer" to high crude oil prices.

25 However, even if biofuels were to displace a mere 1–2 percent of global crude oil supply (2–7 percent of transport fuel demand), they might *moderate* future petroleum price increases.[3] Many factors influence whether such a level of net displacement would occur. Because of the large global potential to produce cellulose, there is much interest in accelerating the development of the required technologies. The U.S. government targets halving the production cost of cellulosic ethanol by 2012, and this would require rapid advances in technology.

Impact of Trade Liberalization

26 Production and trade policies for biofuels and for agriculture cannot easily be separated. WTO negotiations have taken a comprehensive view of what constitutes

[3] This should also be viewed in the context of annual world oil consumption having grown at 1.7 percent in the last decade and likely to maintain a comparable growth rate for the foreseeable future.

trade restrictions and offer a useful framework in which to consider trade policies. The WTO defines trade liberalization to include reducing import tariffs, import quota restrictions, export subsidies, and, significantly, domestic support (subsidies). Subsidies are defined in the WTO Agreement on Subsidies and Countervailing Measures to include not only direct payments to producers, but also reductions in taxes and other charges that reduce government revenues otherwise due.

27 No modeling of global biofuel trade liberalization has been conducted to date, but study findings on liberalizing world agricultural trade are informative. They have shown that the largest gain from liberalizing trade will come from removing border distortions. An estimated 75 percent of total agricultural support to OECD countries is provided by market access barriers and only 19 percent by domestic farm subsidies (Anderson, Martin, and Valenzuela 2006). Meanwhile, in developing countries, nearly all price support is through border restrictions. Several studies have estimated the percentage of the total costs of global distortions in agriculture arising from import restrictions. The results range from about 80 percent to more than 90 percent (OECD 2006c; Diao, Somwaru, and Roe 2001; Anderson, Martin, and Valenzuela 2006). The benefits of reducing distortions go largely to industrial countries because they have the greatest distortions and largest economies. However, when measured as a share of national income, the benefits to developing countries are nearly double those of the industrial countries (Van der Mensbrugghe and Beghin 2005).

28 A study examining removal of U.S. import tariffs on ethanol—keeping all other U.S. policy measures in place—estimates that tariff removal would increase world ethanol prices by 24 percent and raw sugar prices by 1.8 percent, and decrease maize prices by 1.5 percent as less maize is channeled to the U.S. ethanol industry. In the United States, ethanol prices would fall by 14 percent, overall imports would triple, imports from the Caribbean, which currently enjoys duty-free access under the Caribbean Basin Initiative, would cease, and consumption would increase by 4 percent. In Brazil, ethanol consumption would decline by 3 percent and net ethanol exports would increase by 64 percent (Elobeid and Tokgoz 2006).

29 As the above study illustrates, liberalizing biofuel trade is likely to increase demand for biofuels by reducing prices in previously protected markets, especially if the subsidies for consumption, mandates, or both are maintained. An immediate effect of trade liberalization would then be similar to that of higher biofuel production: an increase in feedstock prices and a fall in byproduct prices on the world market. Domestic biofuel prices in those markets that heavily protect domestic producers would fall. More generally, biofuel and agricultural trade liberalization is expected to increase world prices of agricultural commodities. Higher agricultural crop prices would benefit many of the poor engaged in agriculture in developing countries. However, food security in those developing countries that are net food importers will be negatively affected. Prices are expected to rise more steeply for the food products that developing countries import than for the commodities they export. The poorest countries, very few of whom export products on which there are currently high tariffs, would generally be worse off (FAO 2003). Lowering tariffs in developing countries could partially mitigate these

adverse effects by lowering prices of imported food items and by creating opportunities for regional trade.

30 One possible exception to the above price trend is oilseeds and oilseed products, on which some major oilseed producers assess export taxes. Removal of the export taxes may prompt a large supply response and a fall in world prices, and greater exports of biodiesel feedstocks, rather than biodiesel, to industrial countries. Some industry analysts posit that the most competitive structure for the EU biodiesel market might consist of large multi-feedstock facilities in EU countries with good inbound logistics (preferably located near a port) importing feedstocks. These facilities would combine scale, the ability to arbitrage between the various feedstocks and origins, and the ability to blend biodiesel fuels from different feedstocks to comply with the EU fuel specifications and performance requirements.

The Role of International Trade in Biofuels

31 If biofuel production is economic, a producing country would presumably consume any additional biofuel production that the domestic market can absorb before exporting, since selling into the domestic market is virtually universally more profitable than exporting. If production takes place even if not economic, then, from the point of view of maximizing public welfare, the net subsidies provided for biofuel production should approximate the externalities associated with environment and energy security. Any net subsidies above that level or any additional distortions to trade can reasonably be considered protectionism that reduces societal welfare.

32 It is important to distinguish between energy security and energy self-sufficiency in assessing whether current support for biofuel production makes optimal use of public funding. It is also necessary to recognize the global nature of some of the environmental effects of substituting biofuels for petroleum fuels in transportation. In many countries, a policy for energy security is equated with self-sufficiency. This in turn conveniently leads to protection of domestic agriculture in industrial countries since many view development of biofuels as a substitute for agricultural reforms required under international trade negotiations. But energy security objectives might be met by trading with a broad range of countries. Likewise, global environment benefits can be achieved from production and energy substitution anywhere on the globe. The guiding principle, therefore, should be to achieve reductions in GHG emissions at least cost in any sector anywhere. By the same token, ecologically harmful production pathways for biofuels anywhere defeat the purpose of importing biofuels for global environmental gains.

33 There are two questions to be answered in assessing whether liberalizing trade in biofuels might improve economic welfare. First, is there a combination of potential biofuel-deficit and biofuel-surplus countries that might beneficially engage in international trade? Second, how do the existing subsidies in various countries measure up against current best estimates of potential environmental and other benefits? The report suggests that subsidies in a number of countries in the past have probably exceeded the value of potential environmental gains from fuel substitution.

34 The European Union, the United States, Japan, and perhaps a few other countries in Asia might fall into the category of potential biofuel or biofuel feedstock

importers. Most developing countries are densely populated and do not have large tracts of underutilized lands that could be used for crops or biofuels. The potential exporters include some parts of Latin America—notably Brazil, and to a lesser extent Argentina—and sub-Saharan Africa that have considerable surplus land that has not been brought into production. Vast rainforests in Indonesia are also suitable for palm cultivation. There is concern that additional production would occur via the clearing of rainforests and savannas in Latin America, Southeast Asia, and Africa. Such new clearing would result in additional GHG emissions and the loss of existing biodiversity and GHG sinks. Another concern is that water is not valued like energy in most countries. In those regions where water is projected to become increasingly scarce, including parts of Africa, water shortages may become a serious constraint on biofuel production and this merits careful examination. Unutilized land in sub-Saharan Africa faces a number of obstacles before it can be profitably brought into production. These obstacles include poor infrastructure, underdeveloped financial markets, and a hostile investment climate on account of (often inappropriate) government policies and poor governance.

35 If biofuels are not economic but some governments are prepared to offer large subsidies or mandate biofuel use, trade opportunities might arise for countries with duty-free access. Indeed, some transition economies are launching or planning to start biodiesel production with a view to exporting to the European Union. The financial viability of such trade obviously depends critically on the political decisions in the countries providing the subsidies.

36 Biofuel trade liberalization would increase competition, which should in turn help improve efficiency, bring down costs, and enable the world's most efficient producers to expand their market share. Removal of high tariffs would bring down prices in highly protected markets and would increase consumption. While efficient producers would gain, those developing countries with duty-free access to the EU and U.S. markets today might lose their trading opportunities altogether. On the other hand, removing border barriers to biofuel trade, coupled with continued agricultural and biofuel policies that distort biofuel markets, could prolong and even worsen those distortions, as additional markets for subsidized agricultural outputs and biofuels would be created. These considerations underscore the importance of dealing with the full range of trade reforms (defined broadly by the WTO) simultaneously. Failing that, trade in ethanol and biodiesel might be liberalized as a first step, which could also force governments to openly address the question (and the costs) of what objectives their biofuel support policies are actually pursuing.

1

Issues in Biofuels, Agriculture, and Trade

1.1 Bioenergy is playing an increasingly important role as an alternative and renewable source of energy. Bioenergy includes solid biomass, biogas, and liquid biofuels. Combustion of biomass residues for heat and power generation is commercially viable without government support in some applications. Liquid biofuels made from biomass are attracting growing interest worldwide. The global liquid biofuel market today utilizes so-called first generation technologies and relies mainly on agricultural crops for feedstock. Second-generation biofuels, still far from commercially viable, can open up many new opportunities because they can be sourced from a much wider variety of feedstocks, vastly expanding the potential for fuel production and for abating greenhouse gas (GHG) emission. The timing of commercialization is uncertain, although some industry analysts indicate that the needed cost reductions may be achieved in the coming decade.

1.2 This report—which focuses on the issues associated with trade in liquid biofuels—is a second ESMAP report on liquid biofuels and forms a part of the World Bank's broader assessment of bioenergy in general. The previous ESMAP report on biofuels (ESMAP 2005) found the economics of biofuel production and consumption to be site- and situation-specific, suggesting scope for welfare gains from specialization and trade. Recent surges in world oil prices, concerns about energy security, and concerns about climate change from GHG emissions have prompted industrial and developing countries alike to pursue avenues for substituting biofuels for petroleum fuels. One sector in which diversification out of oil is particularly difficult is transport. Unlike heat and power generation, where natural gas, solid biomass, and such alternative sources as hydro-electric or geothermal power can be commercially viable, moving away from traditional liquid petroleum fuels for vehicles (to gaseous fuels or electricity) may require costly modifications to vehicles, fuel distribution, or refueling infrastructure. Liquid biofuels are among the few alternatives that can be readily used by vehicles without significant modification in the existing infrastructure, and for this reason biofuels have been used primarily in the transport sector to date. Argentina, Australia, Brazil, Canada, China, Colombia, the European Union, India, Indonesia, Malaysia, New Zealand, the Philippines, Thailand, and the United States have all adopted targets—some mandatory—for increasing the contribution of biofuels to their transport fuel supplies.

1.3 All liquid biofuel markets to date have been supported by government protection policies that include one or more of the following market interventions: fuel tax reduction or exemption, mandatory blending, producer subsidies, high import tariffs, and financial incentive programs for users of biofuels such as lower taxes on vehicles designed for biofuels. International biofuel trade is beset with both domestic and border distortions. The most frequently cited rationale for these support policies is energy security. In the long run, hydrocarbons are nonrenewable resources and will eventually be exhausted, requiring substitution with alternative sources. In the near term, governments fear scenarios that can lead to a marked or steady increase in world oil prices: disruptions to oil supply through weather conditions (such as Hurricane Katrina in 2005), political events (such as the Iranian Revolution which began in 1978, and more recently the events in Iraq and Nigeria), or unexpected infrastructure breakdown (Alaska in August 2006); higher-than-expected global demand growth without supply expansion to match; and policy decisions by the Organization for Petroleum Exporting Countries (OPEC) to limit supply (as illustrated by the events in 1973–74). These energy security concerns have led to a desire for less dependence on petroleum, and, nearly universally, to greater self-sufficiency in fuel supply in the form of domestic production of biofuels.

1.4 Nearly all liquid biofuels are commercially manufactured from agricultural crops such as sugar cane, sugar beets, maize,[4] cassava, wheat, barley, rapeseeds, soybeans, and palm. As a result, biofuel markets are inextricably linked to agriculture. Policies for biofuels affect agriculture and food production, and agricultural policies affect biofuel markets. This link to agriculture is in fact one of the reasons why there has historically been strong government support for biofuels—a means of protecting domestic farmers. Some biofuel support programs have been started in response to low crop prices. The establishment of Proálcool in Brazil in 1975 has been described by some analysts as a way for the country to address sugar industry overcapacity more than a reaction to the energy crisis (Szmrecsányi and Moreira 1992). In India, overcapacity in sugar production and molasses were the initial motivation for the ethanol program.

1.5 Issues in the liberalization of international trade in liquid biofuels, therefore, cannot be examined in isolation but must be studied in conjunction with related issues in agricultural trade. Crop growers will sell the biofuel feedstocks to the higher-priced of the two markets, agricultural crop or biofuel. Some agricultural products are close substitutes (such as vegetable oils), and some by-products can be manufactured from several different crops, only one of which may be used for biofuel manufacture. An increase in the production of a biofuel feedstock may depress the price of a by-product from another crop which competes on the same by-product market, potentially reducing the overall production of the second crop. Traded and non-traded crops can be produced on the same land and use the same basic inputs. Studies since the 1960s have shown that aggregate agricultural supply response with respect to price is fairly inelastic, but

[4] Throughout this report, the internationally accepted term, maize, is used in the place of corn, which is the term used in the United States. “Corn syrup” is therefore written as “maize syrup,” “corn gluten meal” as “maize gluten meal,” and so on.

individual supply responses are elastic and they respond seasonally to changing price ratios among crops (Binswanger et al. 1987). This means that policies for one commodity are readily transmitted into effects on other crops, and back into inputs—such as land, irrigation water, and fertilizers—that are used for several different crops. Because of crop substitutability, world biofuel trade will be affected not only by the biofuel feedstock market, but also by what happens in other crop markets.

1.6 This report examines policy issues associated with trade in liquid biofuels. To that end, the study poses the following questions:

- What border and domestic distortions protect biofuel manufacturers, including feedstock growers, today?
- How would biofuel trade be affected by agricultural reform?
- How would removing restrictions on international trade of biofuels affect the global biofuel industry and other commodity prices?
- What are the policy lessons from the analysis?

1.7 The report focuses on ethanol and biodiesel, the two most important liquid biofuels, and on commercially demonstrated production technologies for these fuels. The report does not deal with bio-methanol or straight plant oil as a fuel, or with biogas. The report takes a time horizon of the next five to ten years, and does not attempt to assess the impact of policy changes on emerging technologies or new (not yet commercially viable) feedstocks, such as cellulosic ethanol, because these are unlikely to be commercialized within the time horizon considered to have a significant impact on international trade in biofuels. Nor does the report conduct an assessment of environmental externalities that are poorly accounted for, or on specific environmental effects of trade liberalization. This chapter begins with an overview of biofuel basics, the current economics of biofuels, and world consumption of gasoline and diesel (two primary petroleum fuels for which biofuels are substitutes). It follows with a discussion of the global distribution of biofuel production and consumption and the potential role of international trade in achieving efficiency and related objectives. Chapter 1 ends with a discussion of the World Trade Organization (WTO) and on-going negotiations on agricultural and biofuel trade, supplemented by annex 1. Chapter 2, supplemented by annex 2, details the interlinkages between biofuels and agriculture, and reviews trade reforms in agriculture and associated welfare gains, past and future. Chapter 3, supplemented by annex 3, describes government policies that affect important biofuel markets, discusses possible consequences of large expansion of biofuel consumption, and reviews in greater detail policy issues in biofuel trade including WTO negotiations. Chapter 4 concludes with policy lessons and recommendations.

Biofuel Basics

1.8 The two most widely used liquid biofuels are ethanol and plant-oil-based biodiesel. Ethanol can wholly or partially substitute for gasoline, and biodiesel can substitute for petroleum diesel. So-called first-generation biofuels are made from agricultural crops by means of sugar fermentation (for ethanol) and the reaction of methanol (or a higher alcohol) with a plant oil or animal fat. The two most widely used crops for ethanol production are sugar cane (Brazil, Colombia, India, Pakistan, Thailand) and maize (United States, China). Biodiesel is currently made on a commercial scale mainly from rapeseed (Europe) and soybeans (United States). Malaysia, the world's second largest producer of palm oil, is emerging as a new biodiesel producer. There is limited production of biodiesel from animal fats and recycled waste oil, but there is little scope for expanding supply from these sources on a large scale. The United States is the largest producer of ethanol and produces slightly more than Brazil, while Brazil is the world's largest ethanol exporter. The leading manufacturer and consumer of biodiesel is the European Union. Biodiesel has historically been more costly to produce than ethanol and the global production of biodiesel is an order of magnitude smaller than that of ethanol, but growing rapidly.

1.9 Biofuels are typically used in low-percentage blends, in the neighborhood of 5 to 10 percent mixed into petroleum fuels, but they can be used "neat" (pure). Ethanol is dehydrated into a form called anhydrous ethanol before it is blended into gasoline. Vehicles that are manufactured to run on pure ethanol can use hydrous ethanol, which contains about 4–5 percent water. Dehydration of hydrous ethanol into anhydrous ethanol adds to the cost and to the energy used in making the biofuel. Biofuel blends are designated by the amount of the biofuel contained in conventional petroleum products. Letters "E" and "B" are used for ethanol-containing and biodiesel-containing fuels, respectively. For example, the term E10 is used to designate a mixture of 10 percent ethanol and 90 percent gasoline. Gasohol is a gasoline blend containing at least 10 percent ethanol. Similarly, B100 represents pure biodiesel, B5 a blend containing 5 percent pure biodiesel and 95 percent petroleum diesel, and so on.

1.10 Biofuels have several potential environmental advantages. The most important perhaps is a reduction in lifecycle GHG emissions relative to petroleum fuels, since biofuels are derived from plants which convert carbon dioxide (CO_2) into carbohydrates in their growth. The degree of reduction varies markedly with feedstock and the production technology used. Figures from different studies are shown in Table 1.1 and Table 1.2 for ethanol and biodiesel, respectively. The tables give an indication of the degree of divergence of different study findings, with some studies even coming up with opposite signs for the same feedstock. There seems to be a consensus, however, that ethanol from maize in the United States does not give a significant benefit, and can even increase GHG emissions if coal is used to generate electricity consumed during ethanol production. Ethanol from sugar cane, on the other hand, can yield significant GHG emission savings. It is important to note that none of the studies considered changes in land use patterns. If peat land is burned to clear a rainforest to plant palm oil for biodiesel manufacture, for example, there could easily be a net increase, rather than decrease, in lifecycle GHG emissions. Such possibilities are raising increasing concerns in the countries interested in importing biofuels or their feedstocks primarily to reduce GHG emissions, most notably in the European Union.

Table 1.1 Change in Lifecycle Greenhouse Gas Emissions per Kilometer Traveled by Replacing Gasoline with Ethanol in Conventional Spark Ignition Vehicles

Feedstock	*Location*	*Change*		*Source*
Wheat	UK	-47%		Armstrong et al. 2002
Sugar beet	North France	-35%[a]	-56%[b]	Armstrong et al. 2002
Maize, E90	USA, 2015	10%		Delucchi 2003
Maize, E10	USA	-1%		Wang et al. 1999
Maize, E85	USA	-14%[c]	-19%[c]	Wang et al. 1999
Cellulose, E85	USA, 2005	-68%[c]	-102%[c]	Wang et al. 1999
Molasses, E85	Australia	-51%[d]	-24%[d]	Beer et al. 2001
Woodwaste, E85	Australia	-81%		Beer et al. 2001
Molasses, E10	Australia	1%[d]	3%[d]	Beer et al. 2001
Sugar, hydrous ethanol	Brazil	-87%[e]	-95%[e]	Macedo et al. 2004
Sugar, anhydrous ethanol	Brazil	-91%[e]	-96%[e]	Macedo et al. 2004

Note: Percentage changes are for neat ethanol unless indicated otherwise.
[a] Average
[b] Best case
[c] A range given in the study report
[d] Different assumptions about credits for by-product
[e] The first uses average values of energy and material consumption, the second represents best practice

Table 1.2 Change in Lifecycle Greenhouse Gas Emissions per Kilometer Traveled by Replacing Diesel with Biodiesel in Conventional Compression Ignition Vehicles

Feedstock	*Location*	*Change*	*Source*
Rapeseed	Germany	-21%	Armstrong et al. 2002
Rapeseed[a]	Netherlands	-38%	Novem 2003
Soybeans[a]	Netherlands	-53%	Novem 2003
Soybeans[a]	USA	-78%	Sheehan et al. 1998
Soybeans, 2015	USA	173%	Delucchi 2003
Tallow	Australia	-55%	Beer et al. 2001
Waste cooking oil	Australia	-92%	Beer et al. 2001
Canola	Australia	-54%	Beer et al. 2001
Soybean	Australia	-65%	Beer et al. 2001

[a] Biodiesel is imported. Only carbon dioxide emissions are considered.

1.11 Another benefit is a reduction in the emissions of local pollutants at the tailpipe. Ethanol has the greatest air-quality benefits where vehicle fleets are old, as is often the case in developing countries. It helps to reduce the exhaust emissions of carbon monoxide and hydrocarbons, especially in cold climates. Ethanol also has a very high blending[5] octane number (which is a measure of a fuel's resistance to self-ignition—or knocking—when mixed with air in an engine cylinder). It can replace octane-enhancing gasoline additives, such as lead, and can dilute other blending components, such as aromatics, both of which produce pollutants that can be harmful to human health. All biofuels are sulfur-free, an advantage against the backdrop of a worldwide move to reduce sulfur in petroleum fuels for environmental and public health benefits. Biodiesel reduces emissions of carbon monoxide, hydrocarbons, and particulate matter, but can slightly increase emissions of nitrogen oxides (ESMAP 2005).

1.12 Ethanol is a simple molecule and, aside from impurities, its properties are independent of the feedstock from which it is made. It does have some drawbacks. Blending ethanol into gasoline at low levels increases the blend's evaporative emissions. Higher evaporative emissions of hydrocarbons constituting gasoline can be damaging to the environment, especially if the gasoline contains light olefins (which are powerful ozone precursors), in cities where elevated ambient concentrations of ground-level ozone is a public health concern. Gasoline can be manufactured with low vapor pressure to offset the high blending vapor pressure of ethanol, but doing so increases the cost of gasoline production.

1.13 The impact of substituting gasoline with ethanol on vehicle fuel economy varies from vehicle to vehicle and the circumstances. As a broad generalization, a reduction in fuel economy of 20–30 percent can be taken as representative of study findings (ESMAP 2005). The energy content of ethanol is about a third lower than that of gasoline on a volume basis, but the high octane number of ethanol enables a higher engine compression ratio to be used in vehicles designed to run only on pure ethanol, thereby compensating in part for ethanol's lower energy content. Vehicles designed to run on gasoline-ethanol blends and flex-fuel vehicles—capable of running on blends with varying ethanol content—do not have their engine compression ratios optimized for each ethanol-gasoline blend, and as a result their fuel efficiency is lower when running on high ethanol blends than in vehicles designed to run only on ethanol. In assessing prices of ethanol blended into gasoline, several factors need to be considered: (1) a reduction in the fuel economy of 20–30 percent; (2) the higher blending octane numbers of ethanol; and (3) the need, in some regions with tight gasoline quality specifications, to purchase more expensive base gasoline with low volatility to offset the higher blending vapor pressure of ethanol. In this report, as an approximation, the price of ethanol per liter is divided by 0.8 to arrive at a gasoline equivalent price based on the premium grade that would make gasoline and ethanol financially equivalent to consumers on a per-liter basis. The divisor would be smaller for high blends used in flex-fuel vehicles capable of running on varying ratios of gasoline and ethanol (0.7 is typically used as a rule of thumb in Brazil against E20–E25; the divisor would be even smaller when comparing it with pure gasoline). As for biodiesel, one of the most comprehensive reviews found that the impact on fuel economy of using biodiesel was a decrease of 0.9 to 2.1 percent for B20 and 4.6 to 10.6

[5] Because ethanol is typically used in low-percentage blends, properties that are important are blending octane number, blending vapor pressure, and so on. They refer to the effective octane number and vapor pressure, respectively, of ethanol when used in gasoline-ethanol blends.

percent for pure biodiesel (U.S. EPA 2002). This would mean that the price of biodiesel would need to be about 5–10 percent lower than that of petroleum diesel on a per-liter basis to be equivalent.

1.14 Any ethanol added to gasoline needs to be free of water, or else a phase separation can occur between gasoline and water-ethanol. This is the reason anhydrous ethanol is used in a gasoline-ethanol blend. Anhydrous ethanol is transported separately to terminals to minimize contact with water and typically blended into gasoline just before loading into trucks by splash blending, a process that requires no special equipment or temperature control. Ethanol is not typically transported by a nondedicated pipeline because ethanol absorbs water and impurities found in pipelines. This makes long-distance transport of ethanol, such as from the maize-growing U.S. Midwest to California, very expensive, since pipelines, which offer the cheapest mode of shipping fuels long distance, cannot be used and ethanol is instead transported by tanker truck or rail tank car. There is no pipeline transport of ethanol in the United States. Converting ethanol further into ethyl tertiary-butyl ether (ETBE)—as done in France and Spain, and proposed in Japan—enables fuel blending at the refinery gate and avoids these handling problems.

1.15 Ethanol is currently made from the fermentation of six-carbon sugar molecules. The lowest processing-cost and the most efficient pathway is to make ethanol from sugar cane. Sugar cane yields not only six-carbon sugars without any further chemical reactions, but also produces bagasse as a residue during sugar cane crushing. Bagasse is burned for power generation, and enables sugar and ethanol plants to become self-sufficient in electricity and even have some surplus for sale. Sugar beets do not produce the equivalent of bagasse, and thus electricity has to be obtained externally. Molasses, a byproduct of sugar production, typically fetches prices that are lower than equivalent sugar prices. Converting molasses to ethanol can be commercially attractive, enabling sugar processors to attain higher revenues from molasses.

1.16 Conversion of other feedstocks (such as maize, wheat, and cassava) to ethanol requires that starch contained in these feedstocks be first converted to six-carbon sugars, adding to the processing cost. They do not produce residues that can be burned economically to generate power; as with sugar beets, electricity has to be separately purchased or produced. Ethanol from maize produces a number of byproducts depending on the type of milling plant used to produce the ethanol. So-called dry-milling plants use a grinding process and make distillers dried grains which are used as cattle feed. Wet-milling plants use a chemical extraction process and produce maize oil, maize gluten, and high fructose maize syrup. Both types of processing produce carbon dioxide which can be sold commercially. Sales of these byproducts lower the overall cost of ethanol production. In the United States, about 80 percent of the maize used for ethanol production is processed by dry milling plants, and most new ethanol plants are dry mills.

1.17 Biodiesel is made by reacting methanol or ethanol with an oil. Methanol is typically used because it is cheaper. Commercially used oils for biofuel production include rapeseed oil, soybean oil, palm oil, coconut oil, tallow, and waste cooking oil (called "yellow grease" in some places). The bulk of biodiesel is made from vegetable oils. Historically, palm oil prices have been lower than those of other vegetable oils.

Excluding recycled waste oil, palm oil is the lowest-cost feedstock for producing biodiesel today, but these price relationships may change in the future if demand for palm oil rises, as discussed in chapter 3. The Philippines is launching a biofuel industry based on coconut oil, and several countries are experimenting with programs to produce biodiesel from Jatropha curcus and other plants that can survive on marginal land. Biodiesel is not a simple molecule and its physical properties depend on the feedstock. As such, variation in the physical properties of biodiesel fuels is much greater than that of ethanol.

1.18 One disadvantage of biodiesel is its greater tendency to form wax at low temperature and clog fuel filters, posing a technical challenge in cold-climate countries and in winter application in temperate-climate countries. Not all vegetable oils perform similarly as a biodiesel feedstock. Under cold weather conditions, biodiesel made from rapeseed oil outperforms that from palm, soybean, and other oils. There are tests to determine physical properties associated with cold temperature operability. The cloud point is one such measure of cold weather operability limits. The cloud point is the temperature at which a cloud of wax crystals first appears in a fuel sample that is cooled under specified conditions. Petroleum diesel may have a cloud point of –15 degrees Celsius (ºC) to as low as –48ºC, against a cloud point of –2ºC for rapeseed-based biodiesel, 0ºC for soy-based biodiesel, and 15ºC for palm-based biodiesel. Work is underway to address these limitations of biodiesel fuel. The Malaysian Palm Oil Board is reported to have licensed its technology for making EU and U.S. winter-specification compliant biodiesel from palm oil to three of the 52 biodiesel plant license holders and the technology is planned to come on stream by mid-2007 (Reuters News 2006d).

1.19 An interesting development is commercialization of NExBTL (NExt generation Biomass To Liquid renewable diesel) by Neste Oil of Finland. NExBTL employs an entirely different production pathway to manufacture biodiesel from animal fats and plant oils. These feedstocks are not reacted with methanol to make esters (organic compounds containing two oxygen atoms), and NExBTL biodiesel does not contain any oxygen. It is instead a mixture of normal and isoparaffins (the most desirable components of petroleum diesel) with physical properties similar to those of synthetic diesel made from natural gas and coal, and prized for its superior physical properties. NExBTL has a cetane number in the neighborhood of 90, about double the minimum required in most countries, and the production process can be adjusted to achieve a cloud point from -5ºC to -30ºC, thereby overcoming winter-performance problems of conventional ester-forms of biodiesel. Because the components of NExBTL are no different from those of petroleum diesel, there are no materials compatibility issues (Rantanen et al. 2005). Production will start in 2007 and a trial on public transport vehicles in the Greater Helsinki area involving about 700 buses and 75 refuse trucks is expected to last from the autumn of 2007 to the end of 2010 (*Nordic Business Report* 2006).

1.20 Second-generation biofuels can use a much greater variety of feedstocks, including agricultural and forest residues (including unused portions from such current feedstocks as maize and sugar cane, such as maize stover and cane trash), energy crops (such as switch grass), and municipal wastes. Two primary pathways are being pursued. The first breaks down biomass components to make sugars for fermentation into (cellulosic) ethanol. Breakthroughs are needed to bring down the cost of transforming biomass components into sugars. The U.S. government targets halving the production cost of cellulosic ethanol by 2012; this would require rapid advances in technology The second pathway involves heating biomass to a high temperature under controlled conditions to form a liquid directly or a gaseous mixture that in turn is converted into liquids. The latter gasifies biomass into carbon monoxide and hydrogen, which is then converted into a wide array of chemicals, including gasoline and extremely high-quality diesel. The latter, called synthetic diesel, is commercially available today but made from natural gas and coal rather than biomass. The advantage of these "synthetic" liquid fuels—gasoline and diesel—is that they are completely compatible with the current fuel infrastructure and vehicle hardware. These second-generation biofuels open up many new opportunities for energy production because of the vastly expanded scope for feedstocks. At the same time, they involve more complex processing technologies and are likely to require much larger economies of scale—and hence capital investment—compared to first-generation biofuels.

Economics of Biofuels

1.21 Biofuels have historically been more expensive to produce than petroleum fuels, and this is the reason why every biofuel program implemented to date has required significant and ongoing government subsidies, mandates, or both. These policies often are paired with tariff protection to assure that the incentives go only to local producers. The cheapest source of biofuel—based on explicit costs of production that reflect with a lag the "opportunity cost" of using the cane to produce sugar instead—has been ethanol produced from sugar cane in the Center-South region of Brazil. The opportunity cost of a feedstock is a critical and often hidden factor in the economics of biofuel production. This is as true for biodiesel (for example, the cooking oil market versus the fuel market) as it is for ethanol. Thus, when the demand for maize in the alternative market (such as food and the animal feed market) is low and at the same time the demand for sugar is high, ethanol produced from maize can be less costly than ethanol from sugar cane (discussed further in chapter 2). One recent example occurred in June 2000 when sugar prices in Brazil reached their peak. After adding freight charges, U.S. ethanol from maize shipped to Brazil was cheaper by US$0.02 per liter than ethanol made in Brazil (Gallagher et al. 2006). The following paragraphs take the economics of ethanol produced from sugar cane as an illustration of the role that opportunity cost plays in biofuel markets.[6]

1.22 Even in Brazil, at the time the world's lowest-cost biofuel producer, feedstock costs accounted for 58 to 65 percent of the cost of ethanol production in mid-2005. In addition to feedstock costs, other explicit costs include the cost of the capital equipment required for production; the cost of chemicals, labor, and energy used in production; maintenance costs; and the (netted-out) value of the byproducts of the production process. Because the majority of biofuel production costs are in feedstocks, the commercial viability of any biofuel is critically dependent on feedstock prices. In the case

[6] A more detailed discussion of various opportunity costs—including water, land, and labor—can be found in ESMAP (2005).

of ethanol in Brazil, the primary cost determinant is the cost of cane production and the opportunity cost posed by the alternative of producing sugar from that cane.

1.23 Brazil is the lowest-cost producer of sugar cane in the world. Close to one hundred countries around the world are growing sugar cane, but none have been able to match Brazil's sugar cane cost structure. The Center-South region of Brazil, which accounts for 85 percent of the country's cane production, is virtually unmatched in its productivity and low production costs. A number of factors contribute to low-cost and efficient manufacture of both sugar and ethanol in Brazil (ESMAP 2005):

- Cane cultivation is water-intensive, but nearly all cane fields in this region are rain-fed, in contrast to irrigated sugar production in countries such as Australia and India.
- Sugar cane and other activities do not have to compete for land because there is still plenty of land in this region suitable for growing sugar cane that is not currently used for agriculture.
- Productivity in Brazil has also been boosted by decades of research and commercial cultivation. To cite one example, cane growers in Brazil use more than 500 commercial cane varieties that are resistant to many of the 40-odd crop diseases found in the country.
- Most distilleries in Brazil belong to sugar-mill/distillery complexes, capable of changing the production ratio of sugar to ethanol. This capability enables plant owners to take advantage of fluctuations in the relative prices of sugar and ethanol, as well as benefit from the higher price that can be fetched by converting molasses into ethanol.
- Flex-fuel vehicles— introduced in March 2003 and capable of running on any mixture of hydrous ethanol and gasohol—have further increased the attractiveness of building hybrid sugar-ethanol complexes and allayed consumer fears about the consequences of potential ethanol shortages.

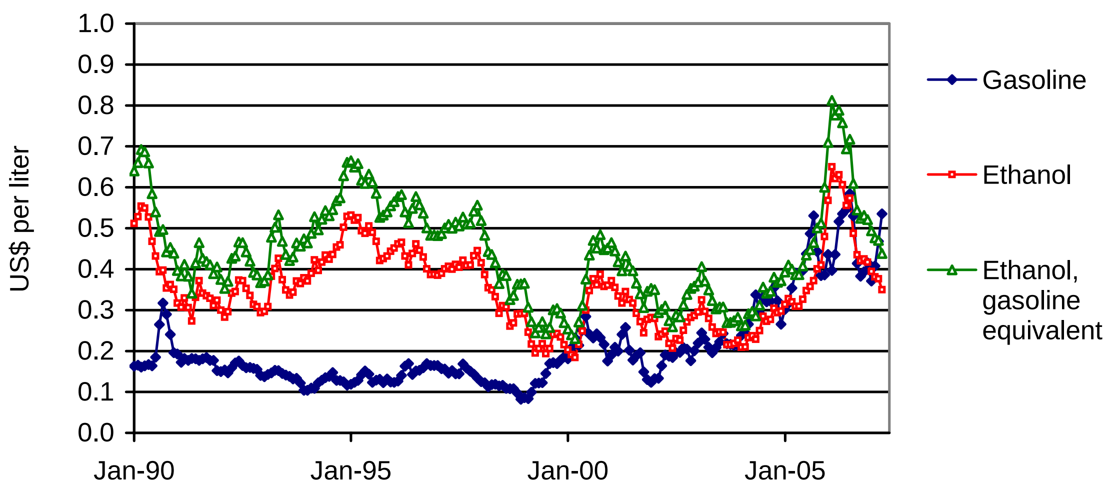
1.24 The financial cost of ethanol production in Brazil was estimated to be in the range US$0.23–0.29 per liter in mid-2005, corresponding to US$0.29–US$0.41 per liter of gasoline equivalent (ESMAP 2005).[7] The (net-of-tax) price—as opposed to the cost of production—of ethanol from sugar cane is determined by the opportunity cost of sugar cane which is the higher of that achieved from selling into the ethanol or selling into the sugar market. World sugar prices reached 25-year highs in early 2006, causing the retail price of hydrous ethanol to exceed that of the gasoline equivalent in Brazil despite a large tax reduction, and prompted the government to reduce the required anhydrous ethanol content in gasohol from 25 percent to 20 percent in March. As the world sugar supply expanded in response and prices began to fall later in the year, the mandatory blending percentage was increased to 23 percent in November 2006.

1.25 At a given world sugar price, the corresponding ethanol price (or opportunity cost of ethanol) can be computed. The results are shown in Figure 1.1 and are compared with Northwest European unleaded premium gasoline prices (wholesale, net-of-

[7] For gasoline equivalent prices, the ethanol prices were divided by 0.7–0.8 in this set of calculations.

tax). During the period covered—from January 1990 to April 2007—world sugar and gasoline prices spanned a wide range, from US$113 to $398 per tonne of sugar and US$0.08 to 0.58 per liter of gasoline, both net of tax. In the figure, two prices for ethanol are shown: on a per liter basis, and converted to gasoline equivalent assuming a fuel economy penalty of 20 percent. The scenario considered is converting sugar cane, which can otherwise yield sugar and molasses, into ethanol, and assumes that molasses fetch 25 percent of sugar prices on a weight basis. The intention here is not to perform precise calculations—which would, among others, require historical world prices of molasses, product yields as a function of technology and sugar cane characteristics, and detailed information on opportunity costs of production and transport costs for moving ethanol and gasoline to markets—but to illustrate patterns for the economics of ethanol production from sugar cane. The results show that, despite high world petroleum prices, soaring world sugar prices made it difficult for ethanol to be economic in 2006.

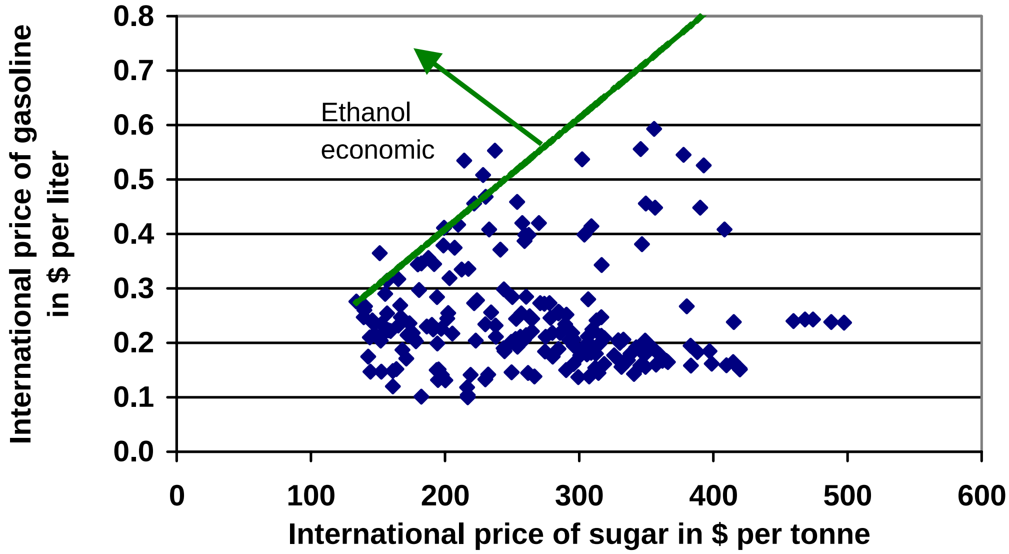
Figure 1.1 Comparison of Gasoline Prices and Opportunity Costs of Ethanol



Sources: World Bank calculations, premium unleaded gasoline in Northwest Europe from Energy Intelligence 2007, raw cane sugar prices from the International Sugar Organization.
Notes: Opportunity costs of ethanol are calculated based on the following parameters used to calculate the equivalencies between sugar and ethanol in Brazil: 1.0495 kg of sucrose equivalent to 1 kg of sugar, and 1.8169 kg sucrose equivalent to 1 liter of anhydrous ethanol. Sugar cane is assumed to yield 83 percent sugar and 17 percent molasses. Prices of molasses are assumed to be equal to 25 percent of sugar prices on a weight basis, and the sucrose content of molasses is 55 percent of that of sugar. Premium gasoline prices are Northwest Europe monthly spot prices, barges, free on board for premium unleaded. Sugar prices are raw, free on board, and stowed at greater Caribbean ports.

1.26 Figure 1.2 plots world sugar and premium gasoline prices in real terms (that is, adjusted for inflation) during the same time period against breakeven gasoline prices (triangles in Figure 1.1): if the price of gasoline is above the breakeven line (solid line in Figure 1.2), then domestic production and consumption of ethanol is economic. During the period covered, again assuming a fuel economy penalty of 20 percent, ethanol broke even only in a handful of months, mostly in 2005.

Figure 1.2 Comparative Economics of Sugar Versus Ethanol Sale (2007 US$)



Sources: World Bank calculations, premium unleaded gasoline in Northwest Europe from Energy Intelligence 2007, raw cane sugar prices from the International Sugar Organization.
Note: For assumptions made in the calculations, see the notes under Figure 1.1.

1.27 Environmental benefits of ethanol that are financially unaccounted for may shift the breakeven line downward. Carbon market payments can serve as an imperfect proxy for the benefits of reducing GHG emissions. But a CO_2-equivalent price range, expected for the foreseeable future, of between US$8 and US$20 per tonne would generally provide only about $0.01–0.07 per liter of biofuel (the upper end of the range for biodiesel), even if 100 percent of the lifecycle GHG emissions of petroleum fuels are assumed to be offset by biofuels. For local air pollution benefits, one set of rudimentary calculations for developing countries suggests that the incremental value of ethanol compared to gasoline may not be much higher than $0.02 per liter, and $0.08 for biodiesel (ESMAP 2005). Biofuel feedstock production and biofuel processing may also carry environmental costs: water and air pollution, soil depletion, and habitat loss and potentially very large GHG emissions associated with the conversion of forests to cropland.

1.28 The foregoing discussion suggests that accounting for environmental externalities might shift the breakeven line in Figure 1.2 by a few cents per liter for ethanol, but would not alter the overall conclusion. As such, Figure 1.2 raises questions about the economics of Brazil's long-standing ethanol program. Brazil is a special case because of its enormous market power in sugar. Although about half of Brazil's cane has been diverted to the ethanol sector in recent years, Brazil still accounts for about 30 percent of world sugar exports. Thus, switching from ethanol to sugar and exporting the additional sugar could lower world sugar prices, just as diverting more sugar cane production to ethanol production could raise world sugar prices further. In fact, as chapter 2 shows, the collapse of the hydrous ethanol market in Brazil before the launch of flex-fuel vehicles, and the subsequent increase in sugar exports, led to a decline in world sugar prices in the late 1990s and early 2000s (as evident in Figure 1.1). Brazil is not in a position to increase sugar production at the expense of ethanol except on a limited basis because of limited sugar milling capacity. The ethanol industry has adopted hybrid mill/distillery configurations capable of adjusting ethanol/sugar percentages within a 20 percent band (40/60 to 60/40 sugar/ethanol), and views sugar and ethanol as joint products. This enables the industry to diversify its product portfolio and mitigate some of the risks of the sugar and ethanol markets. Also, making ethanol at a hybrid mill/distillery complex means that the proportion of molasses in the feedstock not converted to sugar and still fetching sugar-equivalent prices via ethanol is higher, improving economics (although surges in world prices of molasses in early 2006 affected these economics).

1.29 What Figure 1.2 does suggest, however, is that the split between sugar and ethanol in Brazil may not have been optimal, and that, historically, too much cane may have been diverted to ethanol. Had the ethanol and sugar industries been left entirely to market forces, less ethanol might have been produced and more sugar might have been exported, until international sugar prices came down to a level that would make ethanol production economic. This argument would apply only to Brazil. All other countries are effectively price followers in the world sugar market, and the economics of ethanol production would be determined by the solid line in Figure 1.2.[8] Another consideration for Brazil is that, as the world's largest exporter of both ethanol and sugar, export-parity prices of these two commodities affect Brazil's ethanol economics. Since 2002, which includes a period of very high ethanol prices in the United States (in 2006), ethanol has been more profitable than sugar about half the time.

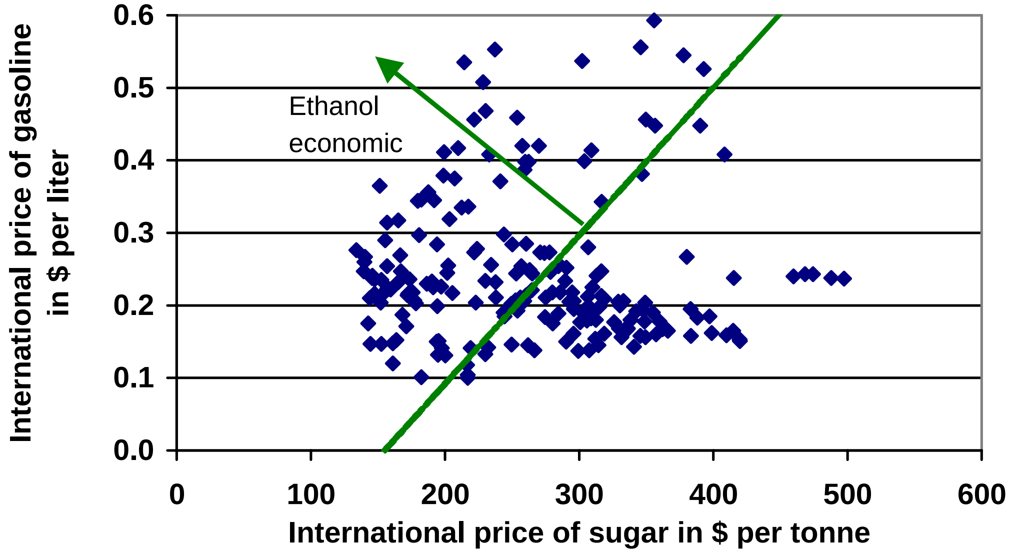
1.30 Ethanol economics should be more favorable in petroleum-importing, sugar-exporting, landlocked areas or any other situation where transportation costs for imports are high and there are indigenous sources of biofuel feedstocks that can be grown at reasonable costs. Export-parity prices of sugar are lower than world prices by the cost of transporting sugar to the nearest external market, and, correspondingly, domestic gasoline prices are higher than world prices by the cost of importing gasoline into the country. For illustrative purposes, a country for which the cost of taking sugar to the nearest port is US$100 per tonne, and that of importing gasoline is US$150 per tonne (US$0.1125 per liter), is considered.[9]

1.31 Under these assumptions, the breakeven line shifts to that in Figure 1.3, and more than half of the data points lie above the breakeven line. Of the 112 months when ethanol was economic, 97 were between September 1998 and April 2007. This would suggest that high world petroleum prices would indeed be favorable for ethanol. However, it is also worth noting that—even in this more favorable case—ethanol was not economic in February and March of 2006 when world sugar prices soared.

[8] In the terminology of economics, analysts should use the "marginal export revenue" rather than the market price for sugar (that is, the "average" export revenue) in calculating the tradeoff between sugar and ethanol production in Brazil and in calculating the economic cost of producing ethanol in Brazil.

[9] US$100 per tonne is the approximate cost to transport sugar from Zambia to the nearest port.

Figure 1.3 Viability of Ethanol for Highly Efficient Producers in Landlocked Areas (2007 US$)



Sources: World Bank calculations, premium unleaded gasoline in Northwest Europe from Energy Intelligence 2007, raw cane sugar prices from the International Sugar Organization.
Note: For assumptions made in the calculations, see the notes under Figure 1.1.

1.32 The foregoing discussion does not consider the cost of sugar production, which, as stated earlier, represents more than half the financial cost of producing ethanol. If the local cost of sugar production is US$250 per tonne, which makes the producer relatively low-cost in global terms, the breakeven line becomes that shown in Figure 1.4. Most of the data points that fall above the breakeven line are from April 2004 or later.

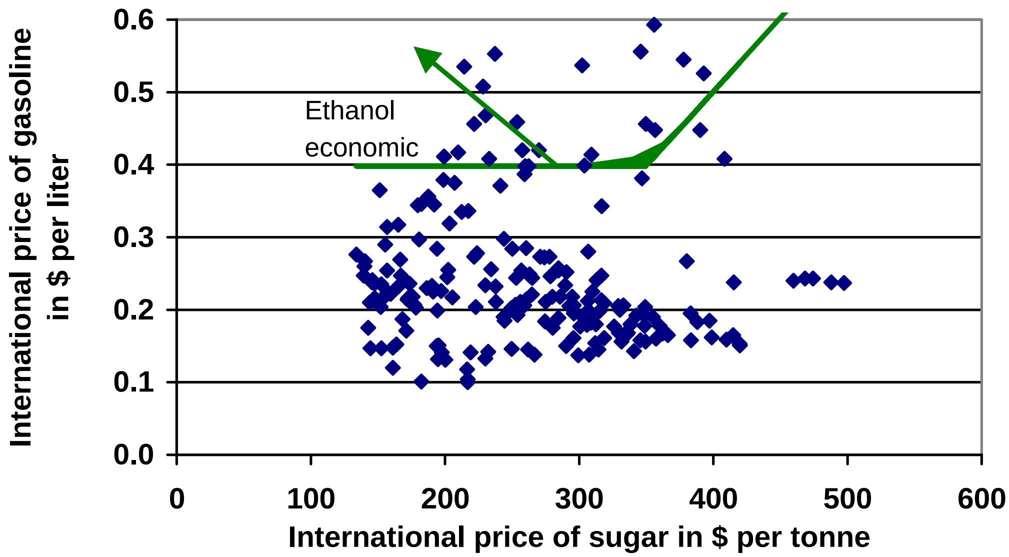
1.33 Table 1.3 summarizes the economics of domestic ethanol production for domestic sale at varying costs of sugar production. Taking costs of production in 2004 to mid-2005, only Brazil, Australia, and Thailand were able to produce sugar at $200 per tonne or lower. Combined, they accounted for 27 percent of world sugar production. Another 23 percent was produced at between $200 and $300, and the remaining 50 percent was produced by high-cost producers, mostly $400 per tonne or higher (ESMAP 2005). The number of landlocked areas with very high transport costs that are also highly efficient producers of sugar cane is limited.

Table 1.3 Economics of Ethanol Production for Domestic Sale in Landlocked Areas, Calendar Years 1990–2006

Domestic sugar production cost per tonne	*US$200*	*US$250*	*US$300*	*US$350*
Percentage of months in 1990–2006 when ethanol production would have been economic	17	8	3	0
Percentage of months in 2004–06 when ethanol production would have been economic	83	42	19	0

Source: Authors' calculations.
Note: For assumptions made in the calculations, see the notes under Figure 1.1.

Figure 1.4 Viability of Ethanol in Landlocked Areas With Sugar Production Cost of US$250 per Tonne (2007 US$)

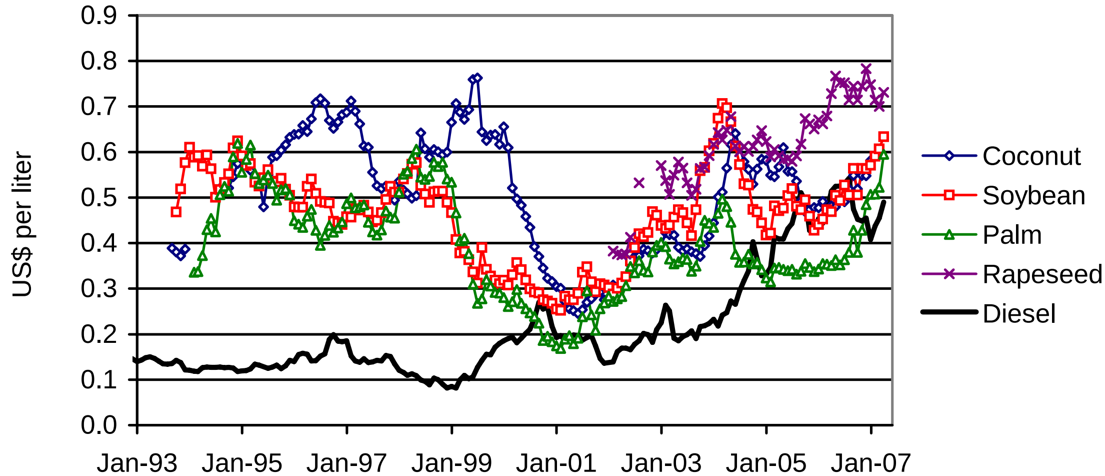


Sources: World Bank calculations, premium unleaded gasoline in Northwest Europe from Energy Intelligence 2007, raw cane sugar prices from the International Sugar Organization.
Note: For assumptions made in the calculations, see the notes under Figure 1.1.

1.34 The economics of biodiesel production and consumption are comparable to those of ethanol in a number of respects. The opportunity cost of feedstocks used to produce biodiesel is the higher of biodiesel or vegetable oil prices in the international market. A liter of vegetable oil produces approximately a liter of biodiesel. In Figure 1.5, world prices for the last dozen years of several vegetable oils that are feedstocks for biodiesel are compared with diesel prices in Northwest Europe. To vegetable oil prices must be added the capital cost recovery for biodiesel plant construction and operating costs, including the purchase cost of methanol. Byproduct sale revenues (the most important byproduct being glycerine) are subtracted from costs and a normal profit margin is added to arrive at the plant-gate cost of biodiesel. This calculated biodiesel breakeven price should be compared to that of petroleum diesel prices. The comparison should take into account the fuel economy penalty associated with using biodiesel and the environmental benefits from reducing environmental externalities, whether the actual fuel prices capture them or not. The figure shows that, even in the face of rising diesel prices, biodiesel has remained relatively expensive: biodiesel feedstock costs have generally been higher than petroleum diesel prices. One notable exception is palm oil since early 2005, although the cost-advantage of palm oil has been rapidly disappearing in recent months.

1.35 Biofuel byproduct prices can have a large impact on biofuel economics. If biofuel byproducts cannot be absorbed easily by the market, byproduct prices may collapse and adversely affect producers of biofuels and other producers of products that compete with the biofuel byproducts. The impact of biofuel production on byproduct prices is discussed in more detail in chapters 2 and 3.

Figure 1.5 Prices of Coconut, Soybean, Palm, and Rapeseed Oils, and Diesel



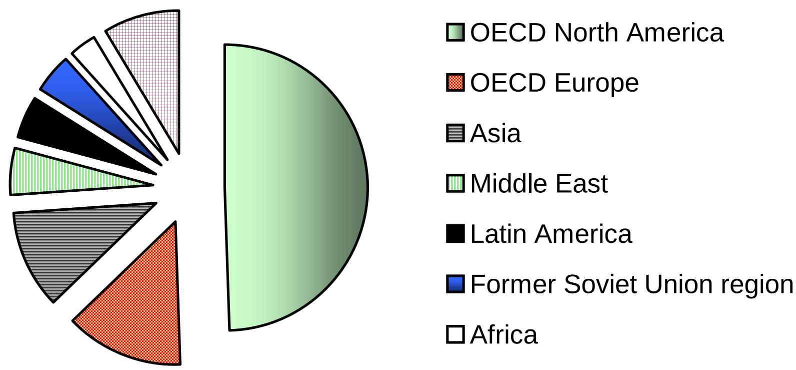
Sources: USDA oilseed data for coconut oil, soybean oil, and palm oil; World Bank Development Economics Prospects Group for rapeseed oil; and Energy Intelligence 2007 for diesel.
Notes: Coconut oil prices are average monthly export values, Philippines; soybean oil prices are for crude oil, tank cars, free on board, Decatur; palm oil prices are crude, delivered, Malaysia and converted from Malay ringitts using the average monthly exchange rate for each month; rapeseed oil prices are Dutch, free on board, ex-mill; diesel prices are Northwest Europe monthly spot prices, barges, free on board for diesel with 0.2 percent sulfur.

Gasoline and Diesel Consumption

1.36 The potential size of the world biofuel market and trade is derived from the market for gasoline and diesel. Worldwide gasoline and diesel consumption in the transport sector in 2004, the most recent year for which global data are available, was 1.2 trillion liters and 0.76 trillion liters, respectively. The United States constituted 43 percent of total world demand for gasoline, the European Union 13 percent, Japan 5.2 percent, and the People's Republic of China 5.2 percent. Turning to diesel, the European Union consumed 27 percent of automotive diesel, followed by the United States at 20 percent, China at 6.5 percent, Japan at 4.4 percent, and Brazil at 4.1 percent (IEA 2006). The percentage figures for consumption of motor gasoline and automotive diesel in 2004 in major regions of the world are plotted in Figure 1.6 and Figure 1.7.

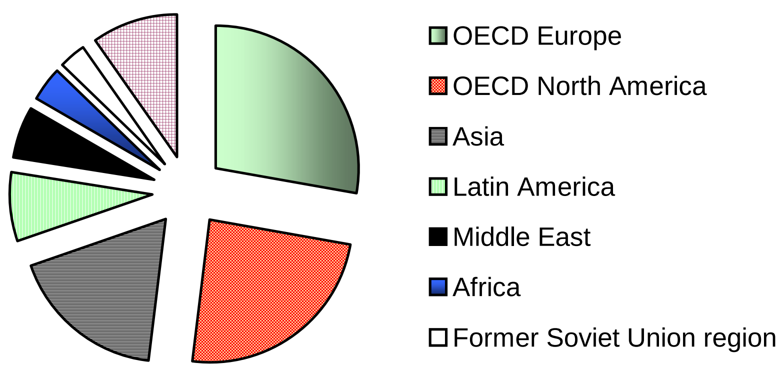
1.37 These consumption statistics, together with the potential for economic expansion of domestic biofuel production, indicate that the largest potential importers of biofuels are the United States and the European Union, followed by Japan. Substituting 5 percent of world gasoline and diesel consumption in 2004 would have required about 73 billion liters of ethanol (assuming an overall fuel economy penalty of 20 percent) and 40 billion liters of biodiesel (assuming a fuel economy penalty of 5 percent). Global production of biofuels was estimated in early 2006 to be more than 35 billion liters (Commission of the European Communities 2006a), or less than one third of what would have been needed to displace 5 percent of world gasoline and diesel fuel consumption in the transport sector.[10]

Figure 1.6 World Motor Gasoline Consumption in 2004



Source: IEA 2006.
OECD North America includes Mexico. FSU former Soviet Union.

Figure 1.7 World Automotive Diesel Consumption in 2004



Source: IEA 2006.

1.38 This chapter concludes with a brief overview of WTO negotiations, and particularly the Uruguay Round Agreement on Agriculture—referred to as the Agreement on Agriculture hereafter. Anything that subsidizes or mandates—and thereby increases—consumption of a product generates new trade, everything else being equal, and in that sense all government support is trade-distorting. But the tradition has been to call a policy "trade distorting" if it has an anti-trade bias or reduces trading opportunities for others in the global trading system (such as domestic subsidies benefiting only domestic

[10] These comparisons do not take into account additional energy needed to grow and harvest crops, manufacture biofuels, and transport them to markets. The effective displacement rate would be lower than 5 percent as a result.

production, import tariffs and other import restrictions, export subsidies, and export taxes). This report uses the phrase "non-trade distorting" to describe policies that do not create an anti-trade bias or reduce global trading opportunities for some. Policies that distort agricultural trade remain much more pervasive and substantial than trade-distorting policies in other goods and services. The Agreement on Agriculture is directly relevant to biofuel trade to the extent that ethanol is classified as an agricultural good by the World Customs Organization (WCO) and the Agreement on Agriculture bases its product coverage on WCO classifications. Further, virtually all commercial feedstocks for biofuel production are agricultural crops at present. Tariffs on agricultural goods remain substantially higher than those on manufactured goods almost everywhere in the world. The global trade-weighted average tariff for agricultural products in 2001 was more than three times the average for all merchandise trade, with almost every country having higher tariffs for agricultural goods than for other goods (CBO 2005). The Agreement on Agriculture under the WTO concerns not only border distortions but also trade-distorting forms of domestic support; as such, it provides a useful framework for considering policy questions for biofuel trade.

WTO Negotiations on Agriculture

1.39 The WTO has 150 members, the majority of whom are developing countries, including 32 least-developed countries. The Agreement on Agriculture was negotiated during the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), the predecessor to the WTO; it entered into force with the establishment of the WTO on 1 January 1995. The Agreement on Agriculture has a provision for its own review and renewal, and renegotiation has been under way for some years. The long-term objective of the Agreement on Agriculture is "to establish a fair and market-oriented agricultural trading system." It recognizes that reform agreements must look beyond import access restrictions and touch upon all measures affecting trade in agriculture, including domestic agricultural policies and the subsidization of agricultural exports. Negotiations are taking place in three areas: reducing domestic support, increasing market access, and reducing export subsidies (WTO 2007).

Domestic support

1.40 In its Agreement on Subsidies and Countervailing Measures, the WTO defines a subsidy as

- A financial contribution by the government whereby it transfers funds or liabilities (such as grants and loans) or there is a potential to do so (as in loan guarantees); forgoes revenue otherwise due (as with tax reduction and credits); purchases goods or provides goods and services other than for general infrastructure; or entrusts a non-governmental body to conduct any one of the above activities and in doing so confers a benefit
- Any form of income or price support, other than that provided through tariffs.

Although WTO negotiations use these definitions in the context of determining whether a subsidy discriminates between domestic and imported goods in favor of the former and distorts trade, they are useful for considering subsidies in general.

1.41 The first pillar of the Agreement on Agriculture aims to reduce these subsidies. The subsidies are divided into three categories or "boxes": (1) the amber box, considered trade-distorting and which governments have agreed to reduce but not eliminate; (2) the blue box, containing subsidies that can be increased without limit, provided payments are linked to production-limiting programs; and (3) the green box, considered minimally or non-trade distorting and not subject to annual limits. They are described in greater detail in annex 1.

Market access

1.42 Market access refers to the reduction of tariff and non-tariff barriers to trade. Ethanol generally encounters much greater tariff barriers than biodiesel. Commodity classifications affect maximum tariff rates that can be imposed in world trade agreements, as well as the pace at which trade liberalization occurs. Classification of ethanol as an agricultural good gives more flexibility to governments to protect their domestic producers through high tariffs and other border restrictions.

Export subsidies

1.43 The Agreement on Agriculture required developed[11] countries to reduce export subsidies by at least 35 percent by value or 21 percent by volume over five years to 2000. At present export subsidies are not a trade policy concern for biofuels.

1.44 Chapter 2 turns to agricultural policies in countries that already have large biofuel markets or are considering mandating biofuels. The chapter focuses on feedstocks that are currently used in biofuel production. Crops that are affected by biofuel feedstocks—because they can be grown on the same land, or because they or their byproducts are substitutable in consumption—are also discussed. The impact of expanding biofuel production on agriculture as well as of liberalizing agricultural trade on biofuel markets is considered.

[11] There are no WTO definitions of developed and developing countries. Members announce for themselves whether they are developed or developing, although the decision of a member to make use of provisions for developing countries can be challenged. The WTO uses the same classification as the United Nations for least developed countries, characterized by low income, weak human assets, and economic vulnerability. In this report, the term "developed countries" will be used in the context of GATT and WTO negotiations. In all other contexts, high-income countries will be referred to as industrial countries.

2

Agriculture and Biofuels

2.1 As stated in chapter 1, ethanol and biodiesel are generally produced from agricultural crops, and feedstock typically accounts for more than half of the production costs. Ethanol, which has the largest market share among biofuels, is produced from starch (cereals) or sugar crops (cane and beets); biodiesel is produced mainly from plant oils (such as rapeseed, soybean oil, and, more recently, palm oil), some animal fats (tallow), and recycled waste cooking oil.

2.2 Brazil is the lowest-cost producer of ethanol from sugar cane and is estimated to have produced ethanol at $0.23–0.29 per liter in mid-2005 and much lower in 2003–04. During the same period, the United States produced ethanol from maize at US$0.27–0.29 per liter.[12] However, feedstock prices have increased—substantially in the case of maize—since these estimates were made. Maize prices rose sharply in 2006, gaining 57 percent in one year and another 6 percent in the first quarter of 2007. Raw cane sugar prices rose from an annual average of US$185 per tonne in 2004 to US$218 in 2005, US$326 in 2006, and $235 during the first quarter of 2007. Thanks to bumper crops in 2006–07 leading to a projected world surplus of more than 7 million tonnes (out of world consumption of about 146 million tonnes), sugar prices are now falling and forecast to remain low for the foreseeable future. Energy prices, which affect the cost of ethanol production in the United States, have also risen, and the Brazilian real has appreciated substantially since 2003. All these events, and particularly crop price increases, have led to a sizable increase in production costs in U.S. dollars. These illustrative figures point to the close association between feedstocks and biofuels and their effects on biofuel economics.

Linkage Between Biofuels and Agriculture

2.3 In examining the linkage between feedstocks and biofuels, it quickly becomes evident that associations between biofuel feedstocks and other crops must also

---

[12] The OECD (2006b) estimated the cost of ethanol production from sugar cane in Brazil at US$0.22 per liter in 2004 and the cost of ethanol production from maize in the United States at US$0.29 per liter. ESMAP (2005) reported the financial cost of ethanol production in Brazil in mid-2005 (at the exchange rate of R$2.40 = US$1.00) to be US$0.23–0.29 per liter, with the range largely reflecting the difference in sugar production costs in different regions. Biodiesel production costs were estimated to be US$0.61 per liter in the EU-15 during 2004 and US$0.55 per liter in the United States by OECD (2006b).

be taken into account. An increase in biofuel production will lead to increased demand for feedstock crops, and is likely to increase all food and feed prices (but lower byproduct prices), at least in the short run. Agricultural commodity prices are highly correlated because cropland can be used to produce different commodities, many commodities are substitutes in consumption, and agricultural commodities are internationally traded and have a single price after allowing for transportation and quality differences. For example, wheat, maize, and soybeans can all be grown in the same areas in the United States, and land is commonly shifted from one crop to another from one year to the next in response to market signals, especially in transition areas where both crops are grown. In Brazil, sugar cane and soybeans can also be grown on the same lands. As a result, prices and production of all of these crops are linked via international markets.

2.4 Consumers also substitute among commodities in response to prices either directly—between food grains such as wheat and rice, for example—or indirectly when livestock and poultry are fed different rations of maize, soybean meal, and wheat in response to market prices. The degree of direct substitution varies between countries and regions and there are still some consumers who are reluctant to switch, but this is slowly changing as more consumers enjoy a more diversified diet. The complexity of interactions among different crops can be seen from an illustration linking rapeseed-based biodiesel, wheat, soybeans, and tapioca. In Western Europe, rapeseed meal will increasingly compete with soybean meal because of rising production of rapeseed for biodiesel manufacture. Soybean meal could, however, benefit from the anticipated limited global wheat supply in the 2006–07 harvest season. On the other hand, tapioca, which is normally used in combination with soybean meal, is in tight supply, partially offsetting what could otherwise be higher demand for soybean meal from reduced wheat supplies (USDA 2006h).

2.5 Processed food products provide yet another link between commodities when alternative sweeteners such as sugar or maize syrup are used to make soft drinks or processed foods. Thus, higher sugar prices arising from diversion of sugar cane to ethanol in Brazil will lead to increased use of high fructose maize syrup in several countries and eventually to higher maize prices in the United States. These relationships are reflected in the correlation coefficients of annual prices shown in Table 2.1 for agricultural commodities commonly used for biofuel feedstocks. The table shows that, on average, if sugar prices rise by 1 percent, maize prices will rise by 0.61 percent. The correlation coefficients are predictably highest for annual crops such as maize, wheat, and soybeans, which can be easily substituted, and lowest for sugar or palm oil, which are produced from perennial crops and are more difficult to switch than annual crops. However, all correlation coefficients shown in Table 2.1 are statistically significant at the 1 percent level. Because of the high correlation between agricultural commodity prices, an increase in the use of any agricultural commodity for biofuel production will affect all commodities after adjustments in demand and supply, and this leads to competition between agricultural commodities for biofuels and agricultural commodities for food and feed.

Table 2.1 Correlation Coefficients for Prices of Crops Used to Produce Biofuels, 1960–2006

Crop	*Sugar*	*Maize*	*Soybeans*	*Palm oil*	*Wheat*
Sugar	1.00				
Maize	0.60	1.00			
Soybeans	0.55	0.92	1.00		
Palm oil	0.56	0.90	0.87	1.00	
Wheat	0.69	0.94	0.91	0.85	1.00

Source: World Bank staff estimates.

2.6 Biofuel manufacture produces byproducts which have economic value as animal feeds, foods, and fertilizers. A good illustration of this occurs in the production of ethanol from maize, since only the starch in maize is used to produce ethanol, with the remaining 30 percent of the maize kernel used to produce other products such as vitamins, food and feed additives, and carbon dioxide. When produced in large quantities, these byproducts can affect the prices of other agricultural commodities and alter the price relationship between commodities.

2.7 There are two different processes used to produce ethanol from maize—wet milling and dry milling—and they produce different byproducts. Dry milling accounts for about 80 percent of U.S. ethanol production and produces a high-protein animal feed byproduct called distillers grains. Distillers grains are fed to beef and dairy cattle and competes with other high-protein feeds such as soybean meal. Wet milling produces maize oil, high-protein animal and poultry feeds, vitamins, and carbon dioxide as byproducts. The byproducts of ethanol production from sugar cane or molasses are similar to the byproducts of producing sugar from sugar cane. The most important byproduct is cane fiber residue (bagasse), which is burned to produce power and steam to operate the sugar factory and power the ethanol plant. This affords a significant cost advantage to ethanol from sugar cane compared with biofuel manufacture from other feedstocks, which typically entails purchasing external energy. The byproduct of biodiesel production is meal in the crushing of oilseeds to make oil, and glycerine in the transesterification process to convert the oil to biodiesel. The meal yield varies from a world average of 78 percent for soybeans to 10 percent for palm (LMC International 2003). Glycerine is used in pharmaceuticals, food and beverages, personal care products, plastics, and foams.

2.8 The United States and Brazil are the world's largest exporters of maize and sugar, respectively. The United States accounts for about two-thirds of world maize exports (68 percent in 2005–06) and Brazil accounts for about one-third of world sugar exports (38 percent in 2005). The rapid increase in ethanol production in these countries has contributed to the recent rise in maize and sugar prices by increasing total demand for these crops and diverting production from traditional food and feed uses. World sugar prices more than doubled from an average of $155 per tonne during 2002–04 to $326 per tonne in 2006, in part due to three years of poor crop performance in Brazil, India, and Thailand. However, the steep rise in world market prices at the end of 2005 and the first half of 2006 has encouraged a strong production response. That, combined with ideal weather conditions around the globe, has led to an estimated increase of 13 million tonnes in world sugar output in 2006–07 to reach 161 million tonnes (Dow Jones Commodities Service 2007d) and falling sugar prices. The world maize market has seen a large impact of the U.S. ethanol program since 2006. Despite three successive years of good maize harvests, maize prices rose 64 percent between January 2006 and March 2007. More than half of the increase in global demand is due to use of maize for ethanol production in the United States. The increased consumption will cause world ending-year stocks to decline by mid-2007 to the lowest levels since 1973 when measured relative to consumption, exerting further upward pressure on maize prices.

2.9 Somewhat offsetting the increase in demand for maize and sugar for ethanol production are government policies that encourage overproduction of these commodities. The United States has a range of support policies for maize and the European Union and the United States have policies that encourage sugar overproduction and depress international prices. The global sugar market is one of the most distorted of agricultural markets, and world prices are estimated to have been depressed by up to 40 percent from the levels that would have prevailed under a free market (Mitchell 2004).[13] Producers in the European Union currently receive triple the historical average world sugar market price—although reforms are under way which will reduce this to “only” twice the historical world market average—while producers in the United States receive about double the historical average world market price. These various policies have slowed the growth of world market imports and encouraged Brazil to divert its sugar cane to ethanol production and away from sugar exports.

Agricultural Policies

2.10 Agricultural policies affect the production, trade, and prices of agricultural commodities and thus are important determinants of biofuel feedstock costs. Historically, agricultural policies have tended to protect producers in industrial countries from imports from lower-cost producers while policies in developing countries have tended to tax exports to fund government budgets. As incomes increase, the pressures for agricultural protection also seem to increase and the highest protection is now found in high-income Asia, the European Union, and the United States. Benefits of government support tend to be capitalized into land values, benefiting land owners.

2.11 Policies in Brazil and the United States affect domestic prices of sugar and maize and thereby influence the profitability of ethanol. Similarly, EU policies for oilseeds are important, but in addition, EU policies on sugar have an effect on world market prices and Brazil’s export opportunity costs for sugar. This section will briefly examine the agricultural policies of Brazil, the United States, and the European Union—three leading producers of biofuels—and their effect on biofuel feed stock prices in order

[13] This estimate is based on a partial equilibrium analysis whereby only the sugar sector is liberalized. If the entire agricultural sector is liberalized globally, the impact on sugar prices would be much smaller. One study found a price increase of about 3 percent (Anderson, Martin, and Mensbrugghe 2006).

to better understand the links between agricultural commodities and biofuels. More details on the EU and U.S. agricultural policies are given in annex 2.

Brazil

2.12 Brazil is the world's largest and lowest-cost sugar cane producer with 428 million tonnes of production in the 2006–07 harvest, forecast to increase to 480 million tonnes in 2007–08 (USDA 2007k). About half of this sugar cane is used to produce fuel ethanol and the other half is used to produce sugar. Ethanol prices in the country tend to increase and become more volatile during the December–April inter-harvest period. Sugar cane production has been increasing at an annual rate of 3.4 percent since 1990 compared with an annual increase of 20 percent in sugar exports. The more rapid growth of sugar exports has been due to shifts of cane from ethanol to sugar as Brazil liberalized controls and reduced subsidies on ethanol production. Further increases in exports will depend on sugar and ethanol prices as well as government policy. The ability to shift production between these alternative uses, within limits, allows Brazil to satisfy domestic demand for sugar and ethanol, and still supply one-third of the world's sugar imports and one-half of the world's ethanol imports. Seemingly unlimited land to expand sugar cane production—at least tripling current production, according to some estimates (Valdes 2006)—all but guarantees that Brazil will be a dominant player in both of these markets for decades to come. Prior to the 1990s, Brazil produced sugar and ethanol under strict government controls that limited exports to surpluses not needed in the subsidized domestic market.

2.13 Brazil embarked on a national fuel ethanol program in response to the oil price shock of the early 1970s. Supply controls and price-setting mechanisms were set up under the program to guarantee the supply of ethanol and sugar to the domestic market and to keep the price of ethanol at levels acceptable to motorists. Credit guarantees and low-interest loans were provided for the construction of distilleries to produce the alcohol. The domestic prices of sugar and gasoline were set in line with the ethanol price. Exports were restricted until domestic requirements were met and prices were controlled so that consumers were insulated from world prices of sugar and fuels. Domestic sugar prices in particular were kept well below world market levels. Under this controlled environment, dedicated cars fueled by hydrous ethanol accounted for more than 90 percent of total car sales in the mid-1980s.

2.14 Controlled low domestic prices for sugar contributed to the pressures for policy reform that began in 1990 with the liberalizing of the sugar export market and the ending of sugar price controls. The government-decreed producer prices for sugar cane were eliminated in February 1999. Policy liberalization led to a surge in sugar exports and a further shift away from ethanol production. At its peak in the 1970s, more than 80 percent of Brazil's sugar cane was used for ethanol production, but this fell to just 30 percent in 1990. This massive shift led to an increase in sugar exports from 1.5 million tonnes in 1990 to 19.1 million tonnes in 2004 (35 percent of world exports) and to a decline in world sugar prices.[14]

[14] World Bank staff estimates based on the FAO Statistical Database (www.faostat.fao.org).

2.15 Agriculture underwent liberalization in the 1990s, but these polices have been partially reversed in recent years. Underlying factors for policy reversal include lower international grain prices, the continuing appreciation of the Brazilian real relative to the U.S. dollar, and higher production costs. The Brazilian soybean sector—targeted for biodiesel production—has faced adverse effects from a drought affecting nearly half the soybean-producing states and from soybean rust (a serious disease causing soybean and other legume crop losses that can destroy up to 80 percent of a crop if left untreated). The net result has been rising production costs, poor credit availability to farmers, and falling soybean area (USDA 2007c). In response, the government has dramatically increased support to agriculture. This support has come mostly in the form of subsidized credit for production, marketing, and investment at long-term interest rates that are about half of commercial rates. These programs vary by crop, region, and producer size. Soybeans have benefited from a line of credit at preferential rates. Exporters benefit from a program that entitles them to receive cash advances from the Bank of Brazil (USDA 2005a).

2.16 The sugar industry receives sugar cane input loans (AE Brazil 2006), and state-specific assistance. *Rio Cana* in the state of Rio Janeiro, for example, has been in place since 2001 to help revitalize the state's sugar cane output. In the 2005–06 harvest season, interest rates on Bank of Brazil loans for the state's independent sugar cane producers averaged about 4 percent for rural families and 8.75 percent for other small producers, and these rates were reduced to 2 percent starting in March 2006, against Brazil's base (overnight) Selic interest rate of 17.25 percent. The state also cut the inter-state and inter-city tax imposed on sugar and ethanol by a large margin, to 2 percent (Dow Jones Commodities Service 2006).

European Union

2.17 The European Union introduced the Common Agricultural Policy (CAP) in 1958 to provide fixed agricultural prices above world market levels to protect farmers in member countries who generally had higher production costs than other world market producers. Despite substantial reform in the 1990s, these policies still exist and provide very high domestic support to EU producers. According to OECD (2006b), the European Union's producer support estimate was 34 percent during 2003–05, of which 50 percent was market price support.

2.18 The Common Agricultural Policy is a supranational and domestically oriented farm policy for EU member countries and has historically heavily influenced EU crop production patterns. The CAP is based on three principles: (1) a unified market in which there is a free flow of agricultural commodities within the European Union; (2) product preference in the internal market over foreign imports through common customs tariffs; and (3) financial solidarity through common financing of agricultural programs. The CAP's main policy instruments include agricultural price supports, direct payments to farmers, supply controls, and border measures (USDA 2006c). Domestic price supports have been the historical backbone of CAP farm support, with prices for major commodities such as grains, oilseeds, dairy products, beef and veal, and sugar depending on the EU price support system.

2.19 Major reform packages have significantly modified the CAP over the last fifteen years. The first reform, adopted in 1992, began the process of shifting farm support from prices to direct payments by reducing support prices, creating direct payments based on historical yields, and introducing new supply control measures. In addition to price support, per-hectare payments are made to certain crop producers based on the average historical yields. Producers of grains, oilseeds, and protein crops are eligible for direct payments if they remove a specified percentage of their area from production. Producers also receive a separate set-aside payment for the areas removed. The area of subsidized oilseed production is limited by the terms of the 1992 U.S.-EU Blair House Agreement, and oilseed producers (except for small producers) are required to set aside a minimum of 10 percent of their land to qualify for payments. The Blair House Agreement limits output from oilseeds planted on set-aside land for non-food (such as industrial and energy, including biodiesel) purposes to 1 million tonnes of soybean meal equivalent a year, if the use of the biomass is guaranteed either by a contract or by the farmer. Because non-food crops are permitted on set-aside land, this policy has encouraged oilseed production for biodiesel manufacture on set-aside land.

2.20 The 2003 CAP reform decoupled income support from production. In particular, crops that were eligible for direct payments only under the non-food regime on set-aside areas may now be cultivated on any area without loss of income support. In addition, the 2003 CAP reform introduced special assistance for energy crops. A premium of €45 (US$61) per hectare is paid, for a maximum guaranteed area of 1.5 million hectares (expanded to 2 million hectares beginning in 2007). If applications exceed the budgetary ceiling, the premium will be reduced proportionally. In 2005, rapeseed production intended for use as biodiesel feedstock was grown on 1.8 million hectares, including 0.9 million hectares of set aside. An estimated 0.5 million hectares received the energy crop payment of €45 a hectare (CRS 2006b).

2.21 Sugar is made from sugar beets in the European Union, a much more costly production process than that from sugar cane. The EU sugar industry is supported through a mixture of price supports, import quotas, and supply controls. CAP support of sugar is restricted to production within a quota, which raises sugar prices for consumers. Intervention buying of raw or white sugar supports the price of the raw commodity (mostly sugar beets). Imports to the European Union are effectively blocked by high tariffs. However, there is duty-free access within a quota for raw sugar from former African, Caribbean, and Pacific (ACP) colonies, and duty-free imports of raw sugar are phased in for least-developed countries until 2009 under the Everything-But-Arms (EBA) trade agreement. After 2009, the least-developed countries will have quota-free and duty-free access. EU sugar policy reform was agreed in November 2005 and began to be implemented in 2006. The reform will reduce the guaranteed price for white sugar by 36 percent over four years beginning in mid-2006. EU farmers will be compensated for 64.2 percent of the price cut, on average, through a decoupled payment. Intervention prices will be replaced by reference prices. Thus prices, instead of being supported directly, will be supported through a private storage system that will act as a safety net, allowing sugar supplies to be withheld when market prices fall below the reference price (European Commission 2005). The reforms also limit subsidized exports to the levels agreed in the

WTO's Agreement on Agriculture and will entail a reduction of exports of 4–5 million tonnes a year from recent levels. These reforms are expected to increase world sugar prices as the EU reduces sugar production and exports, and increases imports.

United States

2.22 The United States introduced commodity policies during World War I and price supports in the 1930s. These policies have had a range of objectives over the years including price and income support, production controls, food aid, export promotion, and environmental protection. According to recent estimates by the Organization for Economic Cooperation and Development (OECD), 17 percent of the value of commodity production at the farm gate was provided by domestic support policies. This includes 20 percent of the value of maize production, 30 percent of the value of wheat production, 18 percent of the value of oilseed production, and 57 percent of the value of sugar production at the U.S. farm gate during 2002–04 (OECD 2005).

2.23 U.S. government support to commodity producers is provided under farm legislation that typically extends for five years. The most recent of these "Farm Bills" was signed in 2002 and is scheduled to expire in 2007. It provides direct government income support to eligible commodity producers, mainly through three programs: direct payments, counter-cyclical payments, and the marketing loan program. In addition, subsidized crop and revenue insurance is provided to assist farmers with risk management. Commodity producers also receive benefits from government programs promoting trade liberalization and food aid. Specific programs apply to individual crops.

2.24 *Direct payments* are fixed payments made annually to farmers who participate in the government program. They are decoupled from production: they are made regardless of the level of production or which of the eligible crops are grown. Eligible crops include maize, soybeans, other oilseeds, sorghum, barley, oats, wheat, upland cotton, rice, and peanuts. *Counter-cyclical payments* are available to farmers whenever the effective price of the eligible crop is less than the target price. The *marketing assistance loan program* provides non-recourse loans to eligible producers, with the farm's program crop used as loan collateral.

2.25 The United States has a range of government policies that support domestic producers of maize and prevent world market price signals from being transmitted to farmers (OECD 2006a, 237–245), this despite the fact that the United States is among the lowest-cost producers of maize net of subsidies. These policies encourage maize farmers to produce even when world market prices are depressed, and keep global maize stocks high and prices low. Removal of all import tariffs and farm support programs—and their distortions of world maize markets—are estimated to result in an increase in average world maize prices of 5.7 percent and an increase in maize trade of 4.5 percent (Fabiosa et al. 2003). This relatively small impact on prices and trade occurs because much of the land devoted to maize production is expected to remain in maize even without government policies, thereby maintaining supply levels. The main impact will be a fall in farm land prices.

2.26 In the United States, incorporated family farms receive the bulk of government farm payments. Program payments tend to be capitalized into the value of farm land, and most of the benefits accrue ultimately to the largest farm land owners, with little of the benefits going to small farmers (IPC 2005). Government subsidies distort market incentives, and this was illustrated in 1999 and 2000 when a shift in land use from maize to soybeans occurred in response to government policies while opposite signals were being given by comparative market prices (CRS 2000). The U.S. policies on renewable fuels are not designated as agricultural policies, but it has much the same effect. Mandates on renewable fuel use, tax incentives to blenders, and tariffs on imports increase the demand for ethanol and biodiesel and increase prices of feedstocks such as maize and soybean oil.

Effects of Biofuel Production on Agricultural Commodities

2.27 The impact of increased production of biofuels on agricultural commodity prices has been examined by the USDA (2007a), FAPRI (2007), and the OECD (2006a). The estimated effects vary due to different assumptions and scenarios analyzed, but the general conclusions are that prices of the agricultural commodities used to produce biofuels would rise sharply while the prices of commodities and products that compete with the byproducts of biofuel production would decline. The former include maize, sugar, and vegetable oils; the latter, soybean meal and substitutes. In addition, prices of meat from animals relying on maize for feed and for which there is a limited scope for substitution—hogs and poultry—will rise more than in the absence of biofuel market expansion. Most other agricultural commodities would see moderate price increases as the production of biofuels increases and in the process draws land and other inputs away from these commodities. These results clearly depend on the assumed or projected level of biofuel production.

2.28 The U.S. Department of Agriculture (USDA) carried out its study in October–December 2006, by which time the impact of the U.S. ethanol program on world maize prices was evident. The study showed that earlier projections might have underestimated the impact of global biofuel programs (see, for example, USDA 2006a). The agricultural baseline projection in the study focused especially on the U.S. biofuel market and assumed that the tax credits available to ethanol and biodiesel blenders and the ethanol import tariff would remain in effect through 2016. Crude oil prices (refiner acquisition cost to be more precise) first fall from US$59 a barrel in 2006 to US$57.5 in 2008, after which they rise gradually to US$73 a barrel by 2016. U.S. ethanol production quickly surpasses the target set by the Energy Policy Act of 2005 of 7.5 billion gallons of ethanol use by 2012 and reaches 12 billion gallons (45 billion liters) by 2016, with the sharpest increase in production occurring by 2009–10. The leveling-off of production in the last several years of the projection period reflects the saturation of the ethanol additive market: above a certain percentage, there is bound to be a sizable price discount for ethanol relative to gasoline because of ethanol’s lower energy content. Twelve billion gallons represent less than 8 percent of annual gasoline demand by volume by 2016, and even less in gasoline equivalent amounts. U.S. biodiesel production is projected to rise to 700 million gallons (2.7 billion liters) by 2011–12. Production levels off after 2011 as higher soybean oil prices reduce profitability. At 700 million gallons, biodiesel will comprise less than 2 percent of U.S. highway diesel fuel use.

2.29 In the United States, the ending stocks for maize fall sharply, and the stock-to-use ratio falls from 17.5 percent in 2005–06 to 4.5 percent in 2009–10, after which it rises gradually to 5.7 percent in 2016–17. Increased demand for maize to produce ethanol raises the price paid to maize farmers to US$3.75 a bushel by 2009–10—about double the price paid in late 2004—after which the farm-gate price is forecast to fall gradually to US$3.30 by the end of the forecast period. The maize price increase between 2005 and 2016 is still nearly double the rate of inflation, although this is in part because of back-to-back large crops of maize (and also soybeans) in the United States in 2004 and 2005. Higher maize prices provide incentives to increase maize acreage at the expense of soybean plantings. Other sources of land for increased maize plantings include cropland used as pasture, reduced fallow, acreage returning to production from the expiring Conservation Reserve Program contracts, and shifts from other crops such as cotton. Higher maize prices also support wheat prices by encouraging increased feed wheat use. Farm-gate wheat prices rise from US$3.42 per bushel in 2005–06 to US$4.35 in 2010–11 (nearly double the rate of inflation) and to US$4.55 in 2014–15 before leveling off. Except for the last year of the forecast period, wheat prices increase at a higher rate than inflation. The soybean stock-to-use ratio declines steadily from 15.6 percent in 2005–06 to 7.4 percent in 2016–17, while farm-gate soybean prices increase 29 percent in nominal terms between 2005 and 2009—more than double the rate of inflation—after which they fall gradually. In real terms, soybean prices rise until 2012, after which they fall. Increased co-production of distillers grains replaces some direct maize use in livestock feed as well as soybean meal in some animal rations. Soybean meal prices in real terms rise to 2009–10 and then subsequently fall significantly. Distillers grains are less suitable in rations for hogs and poultry; the latter will continue to require (now more expensive) maize, pushing up pork and poultry prices. Crop price increases are not sufficient to lead to a significant overall increase in cropland planted to major crops: the planted acreage for eight major crops increases by less than 2 percent between 2005 and 2016. When all food items are considered, U.S. food prices rise more slowly than the consumer price index (as they have done historically).

2.30 The above results for the U.S. domestic market are important for international trade and food prices because the United States remains the world's largest exporter of maize and wheat throughout the projection period, and of soybeans in 2006–2008. Rapid expansion in global production of biofuels changes the price relationships among various agricultural commodities in the next 3–4 years. The U.S. share of world maize trade falls from 60–70 percent to 55–60 percent. Ethanol demand is expected to be inelastic in the range of prices projected in the study. With a greater share of the maize market captured by inelastic demand that is also tied to the world oil market and much smaller stock levels in the United States, the study forecasts increased price volatility, especially in response to weather variability. Global expansion of biodiesel will result in prices of vegetable oils rising more than those of oilseeds and protein meals.

2.31 Rising prices of maize—and potentially of cassava, which is also an ethanol feedstock—would be a concern for the world's poor, most of whom are net food purchasers. Maize is the preferred staple food of more than 1.2 billion people in Latin America and Africa (Global Crop Diversity Trust 2006). Cassava provides one-third of the caloric needs in sub-Saharan Africa and is the primary staple for more than 200 million poor people. Cassava also serves as a reserve when other crops fail. A study at the University of Minnesota estimated that, for every percentage increase in the real prices of staple foods, the number of food-insecure people in the world would rise by more than 16 million (Runge and Senauer 2007).

2.32 The USDA study also examined the impact of ending fuel blenders' credits and the ethanol import tariff. In this alternative scenario, prices of maize, soybeans, soybean oil, and soybean meal fall by 6 to 9 percent by the end of the forecast period relative to the baseline case. Maize planting acreage declines, soybean planting acreage increases, and maize ending stocks, U.S. maize and soybean exports, domestic food use of soybean oil, and domestic feed use of maize all rise at the expense of biofuel use of maize and soybean oil.

2.33 The Food and Agricultural Policy Research Institute (FAPRI) considered only one scenario and incorporated the most likely assumptions into their baseline projection. Although there are no counterfactuals to show the effect of increased biofuel production, FAPRI's modeling results are included here to show the expected growth of biofuels and the overall projected path for agricultural prices to 2016. This study also shows that FAPRI's earlier studies under-estimated the impact of the development of the global biofuel market (see FAPRI 2006). An important difference between the FAPRI and USDA analyses is the future crude oil price trend: the USDA assumed an initial fall followed by a rise to US$73 a barrel by 2016, whereas FAPRI assumed a gradual decline to US$51 a barrel by the same terminal year. As with the USDA, the FAPRI analysis projects that U.S. ethanol production will expand much more rapidly than mandated by the Energy Policy Act of 2005, surpassing 7.5 billion gallons before 2008 and surpassing 12 billion gallons by 2010, after which production plateaus. There is no appreciable increase in the production of ethanol in India and China. China becomes a net importer of ethanol in 2009. Between 2006 and 2016, India's ethanol imports increase by 65 percent, Japanese imports increase by 76 percent, U.S. imports halve, and EU imports more than triple. Brazilian ethanol production increases by 58 percent, consumption by 63 percent (due to the rise in the number of flex-fuel cars), and exports by 35 percent. EU biodiesel production grows slowly because of increasing vegetable oil prices, stagnant crude oil prices, and the gradual phase-down of fuel tax exemption for biofuels in Germany. The use of renewable fuels in the European Union is not expected to achieve the goal of a 5.75 percent share of renewable fuels by 2010 (see chapter 3 for more detail on these biofuel policies). World ethanol prices (taken as Brazilian anhydrous ethanol prices) in nominal terms gradually fall from US$0.48 a liter in 2006 to US$0.36 a liter in 2016. In the United States, ethanol prices fall from US$0.68 a liter in 2006 to US$0.42 a liter in 2016.

2.34 In agricultural trade, the United States exports much more maize—19 percent more in 2016–17—than in the USDA projection, despite having the same harvested acreage and ethanol production between the two studies. U.S. maize ending stocks are also higher in the FAPRI study. Nominal world maize prices (represented as FOB [free on board] in the U.S. Gulf Coast) rise slightly from US$159 per tonne in 2006–07 to US$163 per tonne in 2007–08. They remain at that level until 2010–11 when they begin to fall gradually, reaching US$152 per tonne in 2016–17. Although not exactly comparable, the USDA projection sees nominal farm-gate maize prices rising by 10 percent during the same period. World sugar prices fall by 13 percent between 2006–07 and 2007–08, after which they rise back to the 2006–07 level by 2009–10 and rise another 12 percent by the terminal year; in real terms, world sugar prices fall. FOB wheat prices in the U.S. Gulf Coast fall from 2006–07 to 2008–09, after which they rise gradually but do not recover to the level in the initial year; in real terms, they fall by more than 20 percent.

2.35 World soybean production falls in 2007–08 as U.S. soybean acreage shifts to maize for ethanol, and then continues on an upward trend thereafter. Brazil surpasses the United States as the world's largest soybean producer in 2014–15. Consumption in Argentina (the world's third largest producer and exporter) and Brazil rises, but more slowly than production, resulting in growing exports and in fact a doubling of Brazilian soybean exports (but less than in the USDA study). U.S. soybean exports fall. Soybean prices increase in real terms until 2009–10, after which they fall in both nominal and real terms. By the terminal year, real soybean prices are 17 percent lower than in the initial year. Soybean meal prices fall substantially, 14 percent in nominal terms and 31 percent in real terms. Driven by biofuel demand, world edible oil prices remain strong in the first three years of the projection period. Soybean oil prices in particular soar, more than doubling the price gap between soybean oil and palm oil in 2008–10 compared to that in the initial year. Argentina and Brazil, despite their own domestic biodiesel programs, continue to dominate world soybean oil trade, accounting for 89 percent of total net exports in the terminal year. Palm oil remains the lowest-cost edible oil. Canada dominates rapeseed oil trade, accounting for 92 percent of world trade by the terminal year. Rapeseed oil prices rise in real terms during the first three years, after which they fall. Nominal rapeseed oil prices rise only 3 percent during the projection period.

2.36 The OECD study explored two biofuel scenarios relative to the base case projection that assumed biofuel production would remain constant at 2004 levels. The first scenario assumed the growth of biofuel quantities in line with officially stated national goals on biofuel use in countries with biofuel targets or goals. Nominal crude oil prices were assumed to peak at US$46 per barrel in 2005 and then to decline to US$34 per barrel in 2014 in this scenario and the base case. The second scenario allowed biofuel profitability to determine biofuel production under the assumption of constant crude oil prices of US$60 per barrel from 2005 to 2014. The baseline projection against which these scenarios compare is for relatively constant nominal prices for agricultural commodities through 2014. Wheat prices, for example, are projected to decline slightly from 2005–06 to 2014–15 while rice prices are projected to rise about 8 percent over the forecast period.

2.37 In the first scenario, the prices and trade of most commodities would be affected. Relative to the baseline projection, vegetable oil prices would rise by 15 percent while oilseed meal prices would fall by 6 percent. Sugar prices would rise by 60 percent due to reduced exports from Brazil and increased ethanol production from sugar beets in the European Union. The effects are mostly confined to the commodities that are used as feedstock for biofuel production. Wheat prices, for example, are projected to rise only 4 percent compared with the baseline projection. Sustained higher crude oil prices in the second scenario affected both the cost of agricultural production and the profitability of biofuel production. High crude oil prices would encourage biofuel production but also increase the cost of agricultural production which raised feedstock prices and dampened the profitability of biofuel production. The impact on agricultural commodity prices relative to the baseline was substantial, with nearly all commodity prices affected. Wheat prices are projected to rise about 15 percent, while maize and oilseed prices are projected to rise about 20 percent in nominal terms. Sugar prices have the largest increase of about 85 percent as more sugar cane in Brazil and more sugar beets in the European Union are used for ethanol production.

2.38 Rapidly growing demand for rapeseed oil in Europe has already shifted the price relationship between rapeseed and sunflower oil. Sunflower oil was once the most expensive vegetable oil in Europe, rapeseed oil one of the cheapest. Rising biodiesel demand has altered this relationship, and currently rapeseed oil is trading about US$150 per tonne above sunflower oil. As a result, there is increasing demand for sunflower oil, which is considered a higher-quality oil, and imports into the European Union are growing (USDA 2006h).

2.39 One casualty of rapid growth in biodiesel demand is the glycerine manufacturing sector. Every kilogram of biodiesel produces about 0.1 kg of glycerine. Glycerine prices have dropped by two-thirds in the last five years, and market analysts anticipate downward pressure on glycerine prices to last for the next few years (*EnergyResource* 2006). Falling glycerine prices would adversely affect the economics of biodiesel production. Given these market conditions, glycerine marketers are searching for new applications for glycerine.

Effects of Agricultural Trade Liberalization

2.40 Studies examining the impact of agricultural trade liberalization offer useful insights for the biofuel sector for a number of reasons. First, biofuel feedstocks today are agricultural commodities, and trade liberalization in agriculture would affect their production and prices. Second, because biofuel trade is limited today, there are few studies of the impact of biofuel trade liberalization, but some of the conclusions from studies on global agricultural trade liberalization may be applicable to biofuel trade liberalization. The welfare effect of higher agricultural commodity prices resulting from trade liberalization would be one such example, as higher biofuel production (which could be one outcome of biofuel trade liberalization) is expected to raise agricultural crop prices.

2.41 It is worth pointing out that, in drawing an analogy between agricultural and biofuel trade liberalization, there are similarities as well as important differences. In a number of OECD countries, government support for sugar and biofuels is alike in that they benefit from both border protection and producer subsidies. This package of support measures is unlike that for cotton, which enjoys producer support but no border protection. But biofuels are also afforded consumption subsidies, mainly through tax reductions, and, increasingly, consumption mandates. Consumption mandates as a means of government support have no parallel among agricultural crops. Upon liberalization, production and trade patterns of agricultural crops will shift and overall consumption may even rise. In the case of biofuels, however, absent further cost reductions, both production and consumption may decline sharply if all forms of government support, and especially consumption mandates, are eliminated. In this sense, the welfare gains from liberalization of biofuel trade depend on border protection, subsidies, and consumption mandates. This section of the report assumes that the current protectionist policies for biofuels will continue, and attempts to draw inferences for the impact of reducing "trade-distorting" policies, narrowly defined as policies that create an anti-trade bias or reduce global trading opportunities for some (see paragraph 1.38).

2.42 According to studies of the impact of agricultural trade liberalization, reduced support to agriculture and liberalized trade would provide large welfare gains to both industrial and developing countries. The value of total support to producers in OECD countries was estimated at US$280 billion in 2005 compared to total global trade of agricultural products of US$837 billion (OECD 2006b). The level of producer support fell from 37 percent of farm receipts in 1986–88 to 29 percent in 2003–05 (OECD 2006b), but that reduced level of support was first reached in 1995–97 just after the Uruguay Round Agreement on Agriculture was signed and has changed little since then. The Agreement on Agriculture was signed in 1994 amid high hopes for reforms in agriculture. The Agreement required most member countries to make specific policy changes in domestic price supports, market access, and export subsidies. The main achievement of the Agreement on Agriculture was to include agriculture within the rules and disciplines of the multilateral trading system. The Agreement did not achieve the reforms hoped for because of the wide flexibility afforded in the implementation of the Agreement and the high level of support during the base period of 1986–88 from which future reforms were measured (Ingco and Nash 2004). The Doha Round, launched in November 2001, has encountered the same opposition to reforms in agriculture as previously and the Doha WTO negotiations were suspended in July 2006.

2.43 Potential gains from a successful conclusion of the Uruguay Round were estimated to reach US$270 billion annually, with most of the gains projected to come from agriculture through savings from lower government price supports and lower consumer food prices (World Bank 1994). The largest gains were expected to go to the countries with the highest agricultural protection (the European Union, Japan, Norway, the Republic of Korea, and Switzerland). Developing countries were expected to benefit primarily from lower tariffs on manufactured items and expanded exports of textiles and agricultural goods. The gains from the Uruguay Round reforms have been less than expected, especially in agriculture, because the actual reforms were not as extensive as had been expected. Developing countries have not been able to significantly increase exports of agricultural commodities to industrial countries because tariffs have remained high and quotas on imports have limited market access. However, tariffs in developing countries have declined for both manufactures and agriculture, and this has increased export opportunities among developing countries. According to Aksoy and Beghin (2005), the average tariff in developing countries declined from 22.9 to 18.4 percent for agricultural products and from 16.1 to 11.4 percent for manufactured products from 1995 to 2000.

2.44 Until the 1990s, industrial countries generally protected agriculture while developing countries generally taxed it either directly or indirectly (Krueger, Schiff, and Valdes 1992). Taxes on agricultural commodities focused primarily on exports as a convenient source of revenue, which also helped to keep domestic prices low. However, this pattern began to change with reforms in developing countries. Governments moved away from taxing agriculture, and at the same time liberalized trade in manufactured goods more rapidly than in agriculture, thereby affording greater relative protection to the latter. These changes have come about through eliminating import restrictions and lowering tariffs on manufactured products, devaluing exchange rates, abandoning multiple exchange rate systems that penalized agriculture, and eliminating export taxes. Meanwhile, reforms in most industrial countries have been modest despite the Agreement on Agriculture. Increasing incentives for agricultural production in many developing countries without lowering incentives in industrial countries has led to overproduction and price declines for many agricultural commodities.

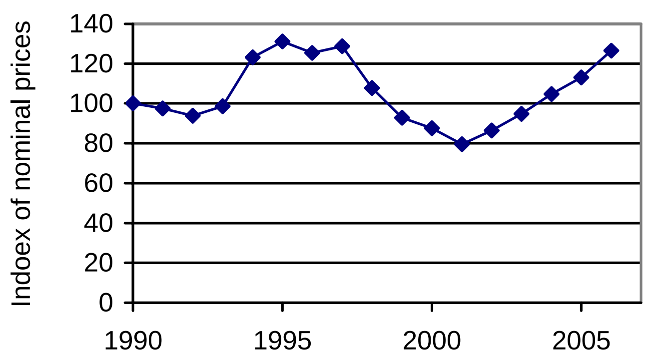
2.45 An important exception to the above development in export tax policy is the oilseed sector. Some major oilseed exporters impose high export taxes to this day—oilseeds, meals, and oils in Argentina (see A3.28 for export taxes in Argentina), crude palm oil in Malaysia, and sunflower seeds in Russia and Ukraine. Should trade be liberalized and these export taxes eliminated, it is possible that there will be a strong supply response, and increased trade and lower prices.

2.46 Argentina, which is the world's second largest exporter of grains after the United States, also imposes high export taxes on grains including maize. Argentina and Malaysia levy low or no export taxes on biofuels, giving incentives to export biofuels rather than biofuel feedstocks. One potential impact of these differentiated export taxes is on the location of investments in biodiesel. Some industry analysts examining the biodiesel market in Europe posit that, in the absence of export tax differentiation, the most competitive market structure might consist of large multi-feedstock facilities in EU countries with good inbound logistics (preferably located near a port) importing feedstocks. These facilities would combine scale, the ability to arbitrage between the various feedstocks and origins, and the ability to blend biodiesel fuels from different feedstocks to comply with the EU fuel specifications and performance requirements. Export tax differentials in favor of biodiesel in surplus countries, however, might result in biodiesel plants being built for export in these countries rather than in Europe.

2.47 About two-thirds of agricultural support to OECD countries is provided through higher prices associated with border barriers while one-third is provided by direct subsidies (OECD 2006b). Meanwhile, in developing countries, nearly all support is through border barriers. Most of the costs of global agricultural distortions are accounted for by a small number of commodities. Rice and beef alone are responsible for the bulk of costs, with sugar (an ethanol feedstock), oilseeds (biodiesel feedstocks), and other livestock products (oil meals and distillers grains being byproducts of biofuel manufacture) accounting for another quarter (Anderson, de Gorter, and Martin 2005). Because the bulk of support provided by non-OECD countries is through border distortions, border protection comprises an even greater proportion of the overall costs of trade distortions when global statistics are compiled. Modeling by one group estimates that 93 percent of the total costs of global distortions arose from import tariffs, while domestic support and export subsidies accounted for an estimated 5 and 2 percent, respectively (Anderson, Martin, and Valenzuela 2006; Hertel and Keeney 2006).

2.48 The impact of the Agreement on Agriculture on agricultural prices appears to have been minimal and most agricultural prices continued to decline from the highs of 1994–95 until 2001 when the global economy emerged from recession. The Asian financial crisis of 1997 contributed to the price declines by reducing incomes and commodity demand in the most affected countries and leading to currency devaluations in major commodity-exporting countries such as Brazil. Prices finally began to recover in 2002 and have since increased due to normal cyclical trends, lower supplies of agricultural products on account of higher crude oil and fertilizer prices, and strong import demand from rapidly growing developing countries such as China (see Figure 2.1). Changes in stock holding patterns by major commodity exporters and importers are expected to lead to increased price volatility in the future as smaller supplies of stocks are available to buffer a production shortfall (Mitchell and Le Vallée 2005).

Figure 2.1 Index of Agricultural Prices (1990 = 100)



Source: World Bank Development Prospects Group.

2.49 Despite disappointing gains from reforms undertaken as part of the Agreement on Agriculture, current estimates of the benefits of agricultural trade liberalization are estimated to be large. Recent work showed that, if all countries removed distortions (border and domestic) in agriculture, the global gains in 2015 would amount to US$265 billion, amounting to nearly 70 percent of the gains from full reform of trade of goods. The benefits of reducing distortions go largely to industrial countries because they have the greatest distortions and largest economies. However when measured as a share of gross domestic product (GDP), the benefits to developing countries are nearly double those of the industrial countries (Anderson, Martin, and van der Mensbruggher 2006).

2.50 The welfare gains from agricultural trade liberalization depend, among other factors, on the baseline used in the computation. For example, higher energy prices and recent biofuels policies that encourage or mandate consumption have raised the level of agricultural prices in international markets and in some domestic markets. Adjusting the baseline accordingly will change the projection of the world economy. How this will affect the estimated welfare gains from agricultural reforms depends on what is assumed about policy responses to fuel and fuel-related price hikes. If there are no changes in ad valorem tariffs on agricultural products, and they are the only means of farm support, then protection levels and their welfare costs will change little. But if farm support is only in the form of deficiency payments, the rise in market prices will lead to a decline in payments from the treasury and hence a fall in the welfare cost of such programs.

2.51 The above qualifications notwithstanding, the studies of the benefits of agricultural trade liberalization suggest that reforms in biofuel trade would likely reduce ethanol and biodiesel prices in countries with high protection such as the United States and the European Union, and increase incomes of countries that export these biofuels such as Brazil. However, the magnitude of the gains cannot be inferred from the studies on agricultural trade liberalization, and these estimates will need to come from additional studies.

2.52 Another important outcome of the liberalization of agricultural trade is the effect on welfare distribution, and there are several illustrative studies on the subject. A study of sub-Saharan African countries estimated that reducing average tariffs from 40 percent to 10 percent would entail a real income loss of 35 percent for urban employers; urban workers who receive trade rents (typically those in protected industries) would lose 41 percent, but rural farmers would receive an income gain of 20 percent. Because rural farmers significantly outnumber affected urban workers and employers, trade liberalization would have an overall positive effect on welfare (Bannister and Thugge 2001). A recent study examined the impact of a 10 percent increase in world sugar prices on the incomes of Brazilian workers. Krivonos and Olarreaga (2006) found that a 10 percent increase would lead to a total income gain of US$5 billion (in 2002 U.S. dollars), or 1.04 percent of GDP, and a decline in the poverty rate of 1.5 percentage points. In the sugar growing and processing sectors as well as other sectors, wages would increase in percentage terms with increasing education. Among those already employed in these sectors, households at the top of the income distribution would experience larger income gains than other income categories due to higher wages. Significantly, however, among those initially unemployed, households at the bottom of the income distribution would experience proportionally larger income gains because many move out of unemployment. As mentioned earlier in the chapter, liberalization of trade in sugar is expected to increase world sugar prices by as much as 40 percent.

2.53 The poor can be adversely affected by agricultural trade liberalization because prices of most agricultural commodities are likely to increase. Those countries that are already integrated into international markets and possess good infrastructure are likely to benefit, but rising agricultural commodity prices could have a negative effect on food security[15] in developing countries that are net food importers. Prices are expected to

---

[15] Food security exists when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. It is usually discussed around three foundational pillars: availability, access and utilization. The self-sufficiency dimension concerns ensuring food availability through domestic production, rather than through domestic production *and trade*.

rise more steeply for the food products that developing countries import than for the commodities they export. The least developed countries, very few of whom export temperate-zone or competing products on which there are currently high tariffs, would generally be worse off (FAO 2003). In all cases, there are intra-country variations in addition to differences across countries. Net buyers of food, including farm workers, will be adversely affected by rising food prices; it is important to note that the negative effects are not confined to urban areas only.

2.54 Developing countries would benefit from lowering their own tariffs on agricultural goods. These tariffs tend to be especially high on essential food items. Lower tariffs would offset, to varying degrees, increases in world food prices following agricultural trade liberalization. Lower tariffs would also enable developing countries to increase trade with each other. For this to happen, reciprocal tariff reductions are necessary. Doing so would create local trade opportunities.

2.55 This chapter covered various aspects of agricultural policies and world trade in agriculture, focusing particularly on agricultural crops that affect, or are affected by, biofuel production. The next chapter treats government policies toward biofuels and issues in international biofuel trade.

3

Biofuel Policy and Trade Issues

3.1 Chapter 2 explored interlinkages between biofuels and agriculture, and discussed past and on-going trade barriers in agriculture and the benefits of removing them. This chapter explores conditions that would increase the potential benefits from trade in biofuels. It begins by reviewing the current status of biofuel policies in the large industrial economies and in the developing economies with current or potential major production of biofuels. The chapter then considers how these policies might affect biofuel trade. It summarizes studies that have examined likely consequences of increasing trade and biofuel consumption. The chapter concludes with policy questions that may be negotiated in the coming years under the auspices of the WTO.

Current Policies for Biofuels that Affect World Biofuel Markets

3.2 All countries that have sizable biofuel markets have adopted policies to promote domestic biofuel production and to promote substitution of biofuels for petroleum fuels in consumption. Among such policies are the following:

- Fuel-tax reductions for biofuels relative to taxes on petroleum products
- Mandatory blending or biofuel consumption requirements
- Import tariffs or quotas on biofuels, paired with preferential waivers of tariffs and quotas for certain countries, largely intended to restrict the access to benefits from biofuel promotion policies to domestic producers and to favored countries
- Price supports targeted at increasing biofuel production
- Production-linked producer payments and tax credits
- Investment incentives such as grants, loans and loan guarantees, and tax-related incentives (tax holidays, accelerated depreciation, tax reductions)
- Funding for research and development (R&D) targeted at increasing biofuel supplies
- Downstream subsidies for vehicles designed to run on high-blend biofuels and for biofuel storage facilities targeted at the “infrastructure” of fuel production and consumption.

3.3 Of the support policies for biofuels, some stimulate consumption and do not in themselves distort trade (except to the extent that they may artificially stimulate it);

two examples are biofuel mandates and fuel tax reductions that do not distinguish between domestic and imported biofuels. Others—such as import tariffs and producer subsidies—clearly protect or subsidize domestic production at the expense of foreign-produced biofuels.

3.4 Among various support measures, fuel tax reductions are most widely used. This instrument critically depends on the presence and the magnitude of excise taxes levied on petroleum fuels. There is an important difference between industrial and developing countries: all industrial countries tax the consumption of petroleum fuels and many levy taxes at rates higher than those commonly found in developing countries, but some developing countries tax little or even subsidize petroleum fuel consumption. In 2005, total fuel price subsidies amounted to nearly US$10 billion in India and Indonesia, both net importers of oil (ESMAP 2006). As the following paragraphs point out, such differences in policy traditions influence the kinds of biofuel promotion policies that individual countries can and do pursue.

3.5 Countries providing price subsidies to petroleum fuels are not in a position to use fuel-tax reduction as a primary policy device for promoting biofuel substitution in consumption. Further, the tax rate levied on diesel—which is used economy-wide in goods and public passenger transport, and the price of which many governments are keen to maintain low—is often low compared with the tax rate on gasoline. That said, some developing countries levy high fuel taxes, primarily for revenue generation. One analysis shows that taxes on petroleum products are a critical source of government revenue for low-income countries (Bacon 2001). The reason is that taxing fuel is one of the easiest ways to obtain revenue: collecting fuel taxes is relatively straightforward, and the consumption of fuels as a group is relatively price inelastic and income elastic, ensuring buoyant revenue as income rises and tax rates are increased. Tax rates on gasoline, generally viewed as a fuel of the rich, tend to be the highest; reducing tax rates on ethanol, a gasoline substitute, could raise fiscal as well as equity concerns.

3.6 Important trade issues that are being negotiated under the WTO include reducing border tariffs, import quota restrictions, producer subsidies, and any incentives offered only to local producers that continue to promote domestic production at the expense of international trade. In WTO parlance, these policies fall under market access and domestic support, two concepts that carry over into biofuel trade policy discussions in this chapter from the comparable discussion of agricultural policies in chapter 2.

3.7 In the following sections of this chapter, biofuel policies are reviewed within the above general framework for the major biofuel markets. The European Union, the United States, and Brazil are covered at some length because these are the largest biofuel markets. The materials on EU and U.S. policies are supplemented by additional information in annex 3. Biofuel policies of India and Malaysia are also discussed in this chapter. India is pursuing both ethanol and biodiesel, and its ethanol mandate policy, which was reversed in 2004 in the face of an ethanol shortage on the domestic market, offers interesting observations. Malaysia, a major producer of both petroleum crude oil and palm oil, is aggressively pursuing biodiesel production for both exports and domestic consumption and has recently introduced a blending mandate. Additionally, Argentina, Australia, Canada, China, Colombia, Indonesia, Japan, and Thailand are reviewed in annex 3. Argentina and Colombia have both mandated biofuel consumption. Australia and Canada have no mandates, but have set national targets for ethanol consumption; in addition, Canada is considering introducing a blending mandate. China is the world's third largest ethanol producer and is expected to become a major player in the global biofuel market. Indonesia, like Malaysia, is a major producer of palm oil and the government has set ambitious targets for biodiesel production and domestic consumption. Japan has no prospect of becoming a significant biofuel producer in the near to medium term and has shown considerable interest in biofuel imports. Thailand, like Brazil, is a low-cost sugar producer and is pursuing ethanol and biodiesel; as such, the difficulties Thailand has encountered in launching an ethanol industry are worth noting.

3.8 It should be noted that data and details of the trade for fuel ethanol are incomplete or non-existent because distinction is usually not made between fuel ethanol and other end-uses of alcohols used in liquors or chemicals. Data are available for ethanol production and trade for all uses, but fuel ethanol can be a small fraction of a country's total consumption, as in India. For these reasons, this report does not attempt to provide quantitative information on fuel ethanol trade (while the volume of internationally traded biodiesel is negligibly small at this time).

European Union

3.9 The European Union produces biodiesel from rapeseed, sunflower, and soybean oil, and ethanol from sugar beets, wheat, and barley. It is the world's largest biodiesel producer; its annual production surged from 1.9 million tonnes in 2004 to 3.2 million tonnes (about 3.6 billion liters) in 2005 (EBB 2007a). EU ethanol production is smaller, rising from 0.5 billion liters in 2004 to 0.9 billion liters in 2005 and to 1.6 billion liters in 2006 (Ebio 2007). Increased use of soybeans, including imported soybeans, in biodiesel manufacture is expected in Germany, Portugal, and Spain in the coming years (USDA 2006h).

3.10 According to the European Commission, domestically manufactured biodiesel becomes economic at crude oil prices of about €60 a barrel, and domestic ethanol becomes economic at crude oil prices of €90 a barrel (Commission of the European Communities 2006a). These economics have historically prompted large tax incentives in countries with active biofuel programs. Under Article 16 of the European Union's Energy Tax Directive, EU member states may exempt or reduce excise taxes on biofuels (EU 2003b). Member states have notified tax reductions in the order of €0.3 (US$0.41) to €0.6 (US$0.81) per liter of biofuel. Significantly, these tax incentives must take into account changing raw material prices so as to avoid over-compensation of biofuel producers (Commission of the European Communities 2006b). The latter principle is intended to avoid the possibility of large windfalls accruing to biofuel manufacturers in times of high world petroleum prices and low feedstock prices. In accordance with this principle, Germany raised the excise tax on biodiesel from zero to €0.09 (US$0.12) per liter beginning in August 2006.

3.11 The European Union issued a Biofuels Directive in 2003, requiring member states to set national indicative targets for the purpose of ensuring that a minimum proportion of biofuels and other renewable fuels be placed on their markets. A reference target value for end-2005 was set at 2 percent, calculated on the basis of energy content, of all gasoline and diesel for transportation purposes, and 5.75 percent by end-2010 (EU 2003a). The 2005 target was not met and recent assessments suggest that the 2010 indicative target is also unlikely to be achieved. This notwithstanding, EU energy ministers agreed in February 2007 to increase the share of biofuels used in transport to 10 percent by 2020.

3.12 The European Commission issued "An EU Strategy for Biofuels" in February 2006 (Commission of the European Communities 2006a). The strategy specifically addressed enhancing trade opportunities and supporting biofuel industries in developing countries. Trade enhancement measures included assessing the benefits and costs of putting forward a proposal for separate nomenclature codes for biofuels, not worsening access conditions for imported bioethanol, pursuing a balanced approach in trade negotiations with ethanol-producing countries and regions, and proposing amendments to the biodiesel standards to facilitate the use of a wider range of vegetable oils for biodiesel production.

3.13 The strategy also stressed the importance of optimizing GHG benefits for the expenditure made, avoiding environmental damage linked to the production of biofuels and their feedstocks, and ensuring that the use of biofuels does not give rise to environmental or technical problems. The annex to the strategy points out that additional production using, for example, virgin savanna in Brazil could cancel out GHG benefits for decades. It also highlights increased pressure on rainforests as the main general negative effect of biofuel feedstock expansion. The decision of the government of the Netherlands to cut the subsidy for "green electricity" produced from palm oil (all of which is imported) has been reported to be driven in part by the negative publicity on the sustainability of palm production in Indonesia and Malaysia (USDA 2006h). The Committee on Industry, Research, and Energy of the European Parliament in October 2006 called for an EU-wide ban on the use of biofuels derived from palm oil. The Dutch government is developing environmental sustainability criteria for the use of biomass, which will also be used as criteria for granting government subsidies. The European Union is also working on possible certification. In response to pressure from the European food industry, major soybean traders in July 2006 declared a two-year moratorium on purchasing soybeans from areas cleared after July 24 in the Amazon forest zone, including soybeans grown on *legally cleared land*. The moratorium agreement also includes an element to ensure traceability of soybeans and to avoid sourcing from farms that are involved in deforestation (USDA 2006k).

3.14 Austria, Lithuania, and Slovenia have mandatory biofuel blending requirements; the mandate is for new fuel marketers only in Austria. Germany and the Netherlands have introduced mandatory blending in 2007. The Renewable Transport Fuel Obligation in the United Kingdom requires oil companies to blend 2.5 percent biofuel in motor fuel by 2008 and 5 percent in 2010–11. In Germany, B100 lost its tax exemption status in August 2006. The tax will increase annually by €0.06 (US$0.08) a liter until 2011. In 2012, biodiesel will be taxed at €0.45 (US$0.61) a liter, which is €0.02 a liter lower than the tax on petroleum diesel. This tax policy change is reported to have led to a sharp decline in the sales of biodiesel and a reduction in output of 30 to 40 percent by the biodiesel industry (*Financial Times* 2007).

3.15 The top three biodiesel producers in the European Union in 2006 were Germany, France, and Italy; the top three EU ethanol producers were Germany, Spain, and France. Germany is by far the largest manufacturer of biofuel; its biodiesel production in 2006 is estimated to be quadruple that of France, the second largest biodiesel manufacturer. The biofuel policies of the three leading producers of biodiesel and ethanol are reviewed in annex 3.

3.16 Biodiesel imports into the European Union are subject to a (relatively low) ad valorem duty of 6.5 percent. In practice, major vegetable oil producers (including Argentina, Indonesia, and Malaysia) are covered under the Generalized System of Preference and have duty-free access to the European Union. A recent development is imports of rapeseeds from Russia and Ukraine for biodiesel manufacture. As for ethanol, a specific import duty of €0.192 (US$0.26 as of April 2007) per liter is levied on undenatured ethanol and €0.102 (US$0.14) per liter on denatured ethanol. In Germany, fuel ethanol imports are eligible to receive the tax concession on fuel ethanol (100 percent of gasoline excise tax) only if the ethanol is imported undenatured. Between 2002 and 2004, 93 percent of ethanol imported into the European Union (for all uses) was undenatured. As explained in annex 3, 101 developing countries enjoy unlimited duty-free access for ethanol exports to the European Union; significantly, Brazil is not among them. In 2004, 55 percent of ethanol imported was free of import duties (Commission of the European Communities 2006a).

3.17 For the reasons described in chapter 1, only biodiesel made largely from rapeseed oil meets the biodiesel standard, EN 14214. Rapeseed biodiesel complies with the standard even if blended with a small amount—for example, 25 percent—of biodiesel made from other oils such as soybean or palm (Commission of the European Communities 2005). In the 2006 "EU Strategy for Biofuels," the European Commission proposed an amendment to EN 14214 to facilitate the use of a wider range of vegetable oils, to the extent feasible without significant ill-effects on fuel performance and respecting the sustainability standards. The Commission will also examine the limits placed on biofuels in petroleum fuels set out in the Fuel Quality Directive—for example, a maximum limit of 5 percent on biodiesel blended into petroleum diesel fuel at present—with a view to enabling greater use of biofuels.

United States

3.18 About 90 percent of U.S. ethanol is made from maize. The remaining 10 percent of ethanol is produced largely from grain sorghum (CRS 2006a). In crop year (September–August) 2005–06, 14 percent of maize was converted to fuel ethanol (USDA 2007a). Biodiesel is made predominantly from soybeans. As with Brazil, there has been steady progress in improving efficiency: thanks to improved hybrid maize varieties and more efficient ethanol plants, for example, one bushel of maize now yields 2.8 gallons of ethanol, up from 2.5 gallons several years ago (*Automotive World* 2006). Approximately 30 percent of gasoline sold in the United States contains ethanol and ethanol constituted nearly 4 percent of total U.S. gasoline supplies by volume (less than 3 percent by energy content) in 2006. Fuel ethanol demand rose from 15.3 billion liters in 2005 to 20.4 billion liters in 2006, against domestic production of 14.8 billion and 18.4 billion liters, respectively (RFA 2007). U.S. biodiesel production tripled in two successive years to 0.28 billion liters in 2005 and to an estimated 0.95 billion liters in 2006.

3.19 Much of the growth in the production of ethanol from maize is thanks to government incentive programs, first begun in 1978. By 1980, 25 states had exempted ethanol from all or part of their gasoline excise taxes (U.S. National Alcohol Fuels Commission 1981). Legislation has also been passed to give income tax credits and loan guarantees to small ethanol producers. Additional information is given in annex 3, and a detailed description of past and present incentives can be found in a report by Koplow (2006).

3.20 In January 2005, the federal ethanol tax incentive was extended through 31 December 2010, at a rate of US$0.51 per gallon (US$0.135 per liter) of ethanol blended, and a federal excise tax credit was also granted to biodiesel blenders. The credit amounted to US$1.00 per gallon (US$0.26 per liter) of biodiesel made from agricultural products and US$0.50 per gallon (US$0.13 per liter) of biodiesel made from other feedstocks such as recycled oils. This tax credit is largely responsible for the surge in the production of biodiesel and in the growth of production capacity. The federal excise taxes on motor gasoline and diesel are US$0.184 and US$0.244 per gallon (US$0.049 and US$0.064 per liter), respectively.

3.21 The Energy Policy Act of 2005 contained a Renewable Fuels Standard requiring a minimum of 7.5 billion gallons (28 billion liters) of renewable fuels to be used annually in gasoline by 2012. The Act also gave additional incentives for cellulosic ethanol and extended the biodiesel fuel excise tax credit through 2008 and authorized a US$0.10 per gallon (US$0.026 per liter) income tax credit to small biodiesel producers (U.S. Congress 2005). In April 2007, the U.S. Environmental Protection Agency (EPA) announced the implementation details, whereby a specified percentage of the total volume of gasoline a company produces or imports must be produced from renewable sources. The percentage is 4.02 in 2007 and increases every year (U.S. EPA 2007). Looking to the future, the Twenty in Ten initiative, promoted by President Bush, aims to reduce gasoline use by 20 percent within ten years by increasing the use of renewable and alternative transportation fuels to the equivalent of 35 billion gallons of ethanol a year by 2017.

3.22 At the state level, 38 states have introduced incentive schemes, including either producer payments or excise-tax reductions. They include mandating government agencies to use biofuels, mandating biofuel use statewide, and providing grants, production tax credits, and other forms of subsidies to the state's biofuel industry. Most renewable fuel standard laws, mandating biofuel consumption, were approved in 2006. The states that have passed legislation include Minnesota, Hawaii, Washington, Montana, Iowa, Louisiana, and Missouri. Some states require minimal state production of biofuels before the mandate becomes effective. Minnesota (ethanol and biodiesel) and Hawaii (ethanol) are the only states at present where biofuel standards are already in effect (see annex 3 for more detail).

3.23 There are other incentives given to biofuel plants. They include accelerated depreciation for biofuel plants, capital grants, loan guarantees, subsidized loans, credit-grant hybrids, regulatory exemptions (environmental impact assessment waiver in Minnesota for ethanol plants less than a certain size, use of eminent domain in Nebraska), and support for land used (for example, reduced property tax rate on ethanol facilities in the state of Washington). There are also incentives given downstream of biofuel production, that is, vehicles and refueling stations. They include tax reductions, tax credits, immediate expensing rather than depreciation over years, and grants (Koplow 2006).

3.24 Koplow (2006) estimated the aggregate subsidy (federal and state combined) to amount to US$5.1 billion for ethanol and $0.38 billion for biodiesel in 2006. Nearly all of the aggregate subsidy for biodiesel and about half of that for ethanol is in the form of the excise tax credit. When expressed in terms of outlay equivalent to take this into account, the aggregate subsidies are US$8.7 billion for ethanol and US$0.48 billion for biodiesel. Averaged over 2006–2012, annualized aggregate subsidies total US$6.3 billion ($8.7 billion in outlay equivalent) for ethanol and US$1.7 billion ($2.3 billion in outlay equivalent) for biodiesel. Per gallon of biofuel, the aggregate subsidies in 2006 are US$1.05 (US$0.28 per liter) for ethanol and US$1.54 (US$0.41 per liter) for biodiesel, rising to US$1.38 (US$0.36 per liter) and US$1.96 (US$0.52 per liter) in outlay equivalent, respectively. The volumetric excise tax credits given by the federal government constitute about half of the aggregate subsidy. A side-by-side comparison of federal tax incentives given to ethanol versus petroleum in the United States was undertaken by the U.S. General Accounting Office at the request of Congress and reported in 2000. The comparison found that, on a per-liter basis, tax incentives given to ethanol were significantly larger (ESMAP 2005, paragraph 3.73).

3.25 Ethanol imports, including ethanol imported directly from Brazil, are taxed at a specific rate of US$0.1427 per liter and also carry an ad valorem import tariff of 2.5 percent for undenatured and 1.9 percent for denatured ethanol (20 percent for countries that do not have a most favored nation status, now called normal trade relations, with the United States). The specific tariff was instituted in the 1980s to prevent foreign producers from benefiting from the fuel excise tax incentive for ethanol. It was intended to be a "temporary" tariff, but has been revised and extended several times. The current tax credit, scheduled to expire in September 2007, has been extended to January 2009. According to the U.S. International Trade Commission, the total volume of undenatured and denatured ethanol imported into the United States surged from 0.8 billion liters in 2005 to 2.7 billion liters in 2006 (USITC 2007). In 2006, the United States bought 1.77 billion liters of ethanol directly from Brazil, or 52 percent of the record 3.4 billion liters of ethanol Brazil shipped out, according to the Brazilian agricultural ministry. The United States also bought 475 million liters of Brazilian ethanol via the Caribbean, or another 14 percent of Brazilian exports (Dow Jones Commodities Service 2007c).

3.26 Under the Caribbean Basin Initiative (CBI), countries in Central America and the Caribbean have had duty-free access to the United States since 1989 for ethanol produced from at least 50 percent local feedstocks. If the local feedstock content is lower, limitations apply but duty-free ethanol is permitted up to 7 percent of total U.S. ethanol consumption for ethanol containing no local feedstock. The upper limit would have amounted to 1.4 billion liters in 2006. This duty-free access has historically prompted hydrous ethanol produced in Brazil and Europe to be shipped to dehydration plants in CBI countries for re-export to the United States. Costa Rica, El Salvador, Jamaica, and more recently Trinidad and Tobago have built and operated dehydration plants for this purpose. The U.S.-Central America Free Trade Agreement (CAFTA) does not increase overall access to the U.S. ethanol market (see annex 3 for more detail). The CBI countries accounted for nearly 50 percent of all ethanol imported into the country in 2005, but their contribution fell to 22 percent in 2006. Brazil accounted for 46 percent in 2004, 34 percent in 2005, and a record 63 percent in 2006 (USITC 2007). Mexico and Canada can also export biofuels to the United States duty-free under the North American Free Trade Agreement (NAFTA).

3.27 In the summer of 2006, against the backdrop of sharply rising ethanol prices, there were growing but unsuccessful calls to eliminate the US$0.1427 per liter import tariff on ethanol. In practice, a loophole allows duty-free imports of ethanol even from countries outside the CBI, NAFTA, and CAFTA regions. Referred to as a manufacturer's drawback, an oil marketer can import ethanol as a blending component to manufacture gasoline, and "draw back" on the duty paid when exporting a like-commodity within two years. Jet fuel is considered a like-commodity and is considered exported when it is used to fill the fuel tanks of an aircraft in the United States destined for an international route. This has allowed oil marketers to add ethanol to jet fuel and recover the import duty paid on ethanol. There are reports to the effect that the amount of the tariff that is ultimately not paid could exceed two-thirds of the total amount due (*Energy Washington Week* 2006a).

3.28 Biodiesel carries a much lower import tariff rate with only an ad valorem charge of 1.9 percent. There is growing concern that some traders are abusing the US$1 per gallon tax credit by importing biodiesel, blending it with a trace of petroleum diesel fuel, collecting the blender's tax credit, and then exporting the resulting blend (*Energy Washington Week* 2006b). The European Biodiesel Board lodged a complaint with the European Commission in March 2007, stating that biodiesel imported into the United States is being spiked with as little as 0.1 percent petroleum diesel, benefiting from the blending tax credit, and exported to Europe at a significant price discount; the amount entering Europe was estimated to be 30,000 tonnes in January 2007 (EBB 2007b). The U.S. National Biodiesel Board issued a statement in April 2007, announcing its intention to pursue legislation, regulatory rulemaking, or both that would make clear that biodiesel involved in re-exporting transactions would not be eligible for the tax credit (NBB 2007).

Brazil

3.29 Brazil, with an ethanol industry dating from the 1930s, vies with the United States for global leadership in ethanol production and is the world's largest ethanol exporter. Brazil produced 17.5 billion liters of ethanol and exported 20 percent in the 2006–07 harvest season (*Dow Jones International News* 2007a). Blending of 5 percent anhydrous ethanol in gasoline was first authorized in 1931 and mandated in 1938. The National Alcohol Program, Proálcool, was launched in 1975. Under Proálcool, the government provided price guarantees, price subsidies, public loans, and state-guaranteed private bank loans to processors and growers. Ethanol and gasoline prices in Brazil were liberalized between 1997 and 1999 (ESMAP 2005). There are no direct production subsidies for ethanol today, but the ethanol industry benefits from both an ethanol mandate and tax reduction, as well as financing provided for stockholding during the inter-harvest periods. As described in chapter 2, the government has been reviving support to agriculture in recent years and some assistance—but not price support—is being provided to the sugar industry at both the federal and state levels. Brazil's ethanol production decisions affect the country's sugar exports which, at one-third of global sugar trade, influence international sugar prices.

3.30 Pure gasoline is not available for sale in Brazil. Fuel purchasers can buy either hydrous ethanol or gasoline containing 20–25 percent anhydrous ethanol. The blending mandate was 25 percent until March 2006, lowered to 20 percent on account of rising world sugar prices, and increased in November 2006 to 23 percent in response to falling sugar prices. In the light of the global surplus of sugar, the government is expected to raise the mandated level to 25 percent in June 2007. Flex-fuel vehicles, capable of running on any mixture of hydrous ethanol and the gasoline-ethanol blend, were launched in March 2003 and reached the two-million mark in mid-2006. They give car owners the option of buying the cheaper (on an energy-equivalent basis) of the two fuels. There is a small tax reduction for the purchase of flex-fuel cars and cars dedicated to run on hydrous ethanol. In 2006, flex-fuel vehicles accounted for 78 percent of all new car sales (ANFAVEA 2007). Nearly all of Brazil's 32,000 filling stations sell hydrous ethanol (USDA 2006b).

3.31 Brazil achieved self-sufficiency in petroleum oil supply in 2006, to which its ethanol program had contributed. Petrobras, Brazil's national oil company, plans to increase its ethanol exports from 320 million liters in 2006 to 850 million liters in 2007. The investment plan includes building pipeline infrastructure to transport ethanol from producing regions to ports. Petrobras' 2007–11 investment program includes exporting 3.5 billion liters of fuel ethanol annually (*BNAmericas Oil & Gas News* 2006).

3.32 Unlike fuel ethanol, the biodiesel industry in Brazil began its first production in 2005. The coordinator for the National Biodiesel Program reported in early 2007 that a total of 24 biodiesel plants would be operational by the end of the year with a combined annual production capacity of 1.3 billion liters (Global Insight Daily Analysis 2007). The program requires 2 percent biodiesel in diesel by 2008 and 5 percent by 2013. This would require 800 million liters of biodiesel by 2008 and approximately 2.4 billion liters by 2013 (*Dow Jones International News* 2007c). The government is looking to the country's soybean production as an important feedstock for its biodiesel program in the near term. Soybeans account for the vastly greater part of Brazilian oilseed production; soybean production doubled between 1993 and 2002. As discussed in chapter 2, the soybean industry has suffered from three years of adverse conditions, but in the coming decade production is expected to rise by more than 60 percent. In the long term, there are other crop possibilities for biodiesel, including palm oil and oil from castor beans (USDA 2006e). There are also concerns among biodiesel producers that Brazilian biodiesel would not be able to compete with biodiesel from Argentina. Petrobras has developed an alternative biomass-based diesel substitute called H-Bio. H-Bio is produced through a process called hydrogenation at petroleum refineries and differs from methyl-ester-based biodiesel: H-Bio is obtained through hydrogenating a mixture of vegetable oil with a petroleum diesel fraction.

3.33 The primary incentive given to promote ethanol in recent years has been a tax reduction for ethanol consumption. Since pure gasoline is not sold, a meaningful distinction in the tax rates between gasoline and anhydrous ethanol cannot be made. Hydrous ethanol, however, enjoys a significant tax reduction compared with gasohol. Several states, including São Paulo—which accounts for 85 percent of ethanol production and more than half of hydrous ethanol consumption—have lower state sales tax rates for hydrous ethanol. A couple of other taxes are lower for hydrous ethanol, resulting in an effective tax difference of R$0.81 (US$0.30 at the time) per liter in June 2005 (ESMAP 2005). A separate assessment estimated the tax reduction in São Paulo in October 2005 to be R$0.80 per liter (US$0.36 at the exchange rate prevailing at the time) (USDA 2006b).

3.34 The import tariff on ethanol from countries outside of Mercosur—a trade bloc consisting of Argentina, Brazil, Paraguay, and Uruguay—was lowered in steps from 22.5 percent in 2001 to 20 percent in 2004. Brazil levies an import tariff of 20 percent on ethanol, which is lifted from time to time if there is a fear of a domestic shortage. For example, in February 2006, as world sugar prices surged and prospects of an ethanol shortage loomed, the Brazilian government lowered the tariff rate to 0 percent temporarily. Mercosur countries enjoy duty-free trade with each other.

India

3.35 In an effort to reduce dependence on imported petroleum oil, which makes up two-thirds of demand, the government has been pursuing biofuel programs for some time. India is a major sugar producer. By regulation, ethanol cannot be produced directly from sugar cane, although this changed in March 2007 when the state government of Bihar amended its Sugarcane Act to produce ethanol from sugar cane juice. Ethanol is produced from molasses, which helps to minimize the impact of the ethanol program on sugar prices, but cross-subsidization between sugar and molasses is an issue.

3.36 Blending 5 percent ethanol into gasoline was mandated in nine sugar-growing states and four union territories in January 2003. To promote the use of ethanol-blended fuel, an excise duty concession of Rs0.75 per liter for E5 was announced in the Union Budget 2002–03, corresponding to Rs15 (US$0.31 at the time) per liter of ethanol. Supply shortages forced India to become the largest importer of ethanol from Brazil in 2004–05. In response to higher-than-anticipated ethanol prices, the government issued a gazette notification in October 2004 making ethanol blending optional, contingent on the delivery price of ethanol at a given location being comparable to the import-parity price of gasoline. Three states stopped selling ethanol in December 2004. The government announced that 5 percent blending would be mandatory from October 2006 in 20 out of India's 27 states, requiring about 600 million liters of ethanol in total, but the implementation deadline has been postponed several times. Production of fuel ethanol fell from 180 million liters in 2002–03 to 90 million liters in 2003–04 and further to 20 million liters in 2004–05, before rising to 200 million liters in 2005–06. Subsidized loans of up to a maximum of 40 percent of the project cost are available for establishing ethanol production facilities from the Sugar Development Fund held by the government, but there is no direct financial assistance for the production or marketing of ethanol (USDA 2006i).

3.37 After being a net importer for the last two years, India became a net sugar exporter in 2005–06, but concerns about domestic supply shortages prompted the government to ban sugar exports from June 22, 2006 to January 22, 2007. The sugar sector is one of the most controlled agribusiness sectors in the country. The government establishes a minimum support price for sugar cane every year, Rs802.5 (US$19) per tonne in 2006–07, and some sugar cane growing states mandate a higher minimum price for cane ("state advised prices"), as high as Rs1,320 (US$31) per tonne in 2006–07 (USDA 2007l). Agriculture in India, including the sugar industry, benefits from subsidies given to power, water, and fertilizers. On the whole, India does not possess comparative advantage in sugar cane production: the country faces agricultural water shortages and sugar cane cultivation is water-intensive. Without government export incentives, Indian sugar is said to be uncompetitive in the international market (USDA 2007l).

3.38 The purchase price of ethanol has been an issue. The price of ethanol sold to oil marketing companies was fixed in May 2005 at Rs18.75 (US$0.43 at the time) per liter. Negotiations on increasing the ethanol price became gridlocked in August 2006 with ethanol manufacturers asking a new price of Rs27.83 (US$0.60) per liter, and the matter was referred to the agriculture and petroleum ministries (*Business Standard* 2006). In November 2006, a price of Rs21.50 (US$0.48) per liter of ethanol was offered to, and accepted by, the Indian Oil Corporation, corresponding to US$0.60 per liter of gasoline equivalent, considerably above premium gasoline prices in the Arab Gulf of US$0.38 in October.

3.39 Thanks to high sugar prices and good weather conditions at the time of planting, sugarcane production rose by 12 percent to a record 315 million tonnes in 2006–07. Domestic prices fell below production costs in response, creating a crisis for the sugar industry. One way to reduce the surplus would be to divert cane to ethanol production, but the agreed price of Rs21.50 a liter was considered too low by many cane growers and one industry estimate suggested in April 2007 that the ethanol blending program was running at only 30 to 40 percent of the target (Reuters News 2007).

3.40 The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Andhra Pradesh has been engaged for some years in R&D to develop high-sugar sweet sorghum varieties particularly suited for ethanol production, and technology for converting sweet sorghum into ethanol. ICRISAT has formed a public-private partnership with Rusni Distillery to set up an ethanol plant with a daily capacity of 40,000 liters using sorghum varieties it has developed. Sweet sorghum can be grown with much less water than sugar cane. ICRISAT is sharing its technical know-how with the Philippines, and Rusni Distillery is participating in an ethanol project based on sweet sorghum in Uganda (*Manila Bulletin* 2006).

3.41 India is also actively promoting fuel switching from petroleum diesel to biodiesel. A National Mission on Biodiesel has been proposed. The Ministry of Petroleum and Natural Gas announced a biodiesel purchase policy in October 2005, in which petroleum marketing companies are required to purchase biodiesel at Rs25 per liter (US$0.56 a liter at the time, or US$89 per barrel of biodiesel) through twenty select purchase centers, beginning January 2006. Biodiesel manufactures protest that Rs25 per liter is not commercially viable, given that the cost of biodiesel production from Jatropha curcus seeds is Rs30–40 (US$0.71–0.95 as of April 2007) per liter (Financial Times Asia Africa Intelligence Wire 2006). Rs30–40 is significantly higher than international prices of diesel. One attraction of Jatropha curcus is that it can grow on marginal land with little rainfall, but experience to date seems to suggest that the plant does not grow under marginal conditions in any commercial sense. The advantages of relying on Jatropha curcus—and other similar plants that are said to be drought-resistant—are not yet clear.

3.42 The Ministry of New and Renewable Energy, in the draft National Policy on Biofuels, suggested a range of fiscal incentives in October 2006. The proposed incentives reportedly include excise duty exemption to biofuels in pure and blended form up to a certain percentage, customs and excise duty exemption for manufacturing plants and machinery used for processing oil seeds for biodiesel production, excise duty exemption for biodiesel blended with petroleum diesel (similar to the concessions given to ethanol blended into gasoline), and establishment of a National Biofuel Development Board to set a minimum support price for non-edible plant oil seeds used as biodiesel feedstocks (Press Trust of India Limited 2006).

3.43 India's first commercial launch of biodiesel occurred in December 2005 in Maharashtra, derived from karanja seeds. In February 2006, UK petroleum company BP announced that it was launching a US$9.4 million, 10-year project on biodiesel from Jatropha curcus in the state of Andhra Pradesh. Cleancities Biodiesel India is expected to start operating what will be India's largest export-oriented biodiesel manufacturing plant by July 2007, using mostly imported feedstock. The plant's initial output capacity will be 250,000 tonnes, to be doubled to 500,000 tonnes in 2008 (Dow Jones Commodities Service 2007b).

3.44 India imposes high import tariffs on agricultural commodities, including vegetable oils, and biofuels. In fiscal year 2006–07, the Central Board of Excise and Customs lists the customs tariff rate on undenatured ethanol (2207.10) as 182 percent, that on denatured ethanol (2207.20) as 30 percent, and that on biodiesel (3824.90) as 12.5 percent (CBEC 2006) (for explanations of 2207.20, 2207.10, and 3824.90, see paragraph 3.70). A June 2006 USDA report lists *total* existing import duties on denatured ethanol, undenatured ethanol, and biodiesel as 253–605, 52.24, and 36.82 percent of the landed value (USDA 2006i). These percentages are very high and appear to include other taxes. A recent government report states that ethanol imports for potable purposes attracts a customs duty of 150 percent, but the customs duty for ethanol imports for use by the chemical and the petroleum industries is 10 percent (Planning Commission 2006). The import tariff on raw sugar consists of a 60 percent ad valorem duty and a countervailing (sic) duty of Rs850 (US$20) per tonne in lieu of local taxes and fees imposed on domestic sugar (USDA 2006d). Concerned about rising domestic sugar prices at the time, the government lifted import duties on sugar from June 23 to September 30, 2006 (USDA 2007l). The government also lowered the tariff rate on crude palm oil from 80 percent to

70 percent in August 2006 (*Business Times* 2006), to 60 percent in January 2007, and to 50 percent in April 2007 (Dow Jones Commodities Service 2007e).

Malaysia

3.45 Malaysia has historically been the world's largest palm oil producer, although it is being overtaken by Indonesia. Malaysia is a net exporter of petroleum crude oil, with petroleum consumption about 60 percent of production in 2005. Malaysia subsidizes the domestic price of certain petroleum products. In 2005, despite several price increases, the total subsidy borne by the government increased to 6.6 billion ringitts (US$1.7 billion). Domestic petroleum fuel prices were last raised in February 2006, but remain below parity with international prices (ESMAP 2006).

3.46 Prime Minister and Minister of Finance Badawi in his 2006 budget speech announced a range of biofuel initiatives, including the introduction of B5 on a pilot basis; the development of biodiesel fuel specifications; construction of three palm-oil biodiesel plants with a total annual capacity of 180,000 tonnes, principally for export; and tabling of a biofuel act in the parliament in 2006. The first commercial-scale biodiesel plant went into production in June 2006. By mid-2007, 20 new biodiesel plants were expected to be in production in Malaysia (*Platts Oilgram News* 2006), but these construction plans have fallen considerably behind schedule. Concerned about the availability of crude palm oil for food and oleochemicals sectors, the government suspended new licenses in July 2006, by which time fifty-two manufacturing licenses had been granted by the government. The government estimated in 2006 that annual biodiesel production capacity would increase to 1.2 million tonnes in 2007; most of the produced biodiesel would be exported (AFX Asia 2006b). As of April 2007, six plants with a combined annual capacity of 300,000 tonnes were operational, and another plant with an annual capacity of 100,000 tonnes was scheduled to come on stream by June (USDA 2007m). As Figure 1.5 shows, palm oil prices have been rising sharply in recent months, slowing down the growth of the biodiesel industry.

3.47 In April 2007, the Parliament passed a Biofuels Industry Bill, requiring blending of palm olein (the liquid fraction obtained by fractionation of palm oil after crystallization at controlled temperatures) in petroleum diesel. Referred to as Envo Diesel, B5 in this Act is a mixture containing not a fatty acid methyl ester formed by reacting methanol with a plant oil, but palm olein (USDA 2007m) and petroleum diesel. While blending palm oil directly reduces the fuel cost by avoiding transesterification, vehicle manufacturers have expressed fears that the fuel may have lower oxidation stability and consequently the life of fuel injectors and injection pumps may be shortened. In September 2006, the Malaysian Automotive Association, which represents almost all local auto distributors, reportedly expressed unease about blending unesterified palm oil into petroleum diesel. The association cited concerns about potentially more frequent breakdowns and repairs, which in turn would affect vehicle warranties (AFX Asia 2006a).

3.48 The government's fuel pricing policy poses a challenge to the domestic biodiesel market in the near term, but Malaysia, like Indonesia, nevertheless is in a position to become an important exporter of biodiesel. The Indonesian and Malaysian governments jointly announced in July 2006 that each would commit six million tonnes annually of crude palm oil for biodiesel manufacture. The commitment, which stopped short of an official mandate, represents about 40 percent of each country's respective annual production of crude palm oil. Some industry analysts have expressed fear that this and other similar moves for increasing biodiesel production could make palm oil too expensive for both food and fuel (Reuters News 2006b).

3.49 In response to growing concerns about adverse environmental effects of expanding palm oil plantation into rainforests, some 185 private sector companies and industry groups, including Malaysian and Indonesian palm oil associations, have formed the Roundtable on Sustainable Palm Oil (RSPO). RSPO is formulating sustainability criteria and certification procedures.

Potential Benefits of Biofuel Trade

3.50 For the consumption of biofuels to be economic, marginal costs of production should be comparable to, or lower than, those of their substitutes—petroleum fuels—after suitably accounting for differences in their respective externalities. Until recently, this condition was seldom satisfied for ethanol and practically never satisfied for biodiesel. In 2005, ethanol from sugar in Brazil was competitive at the economic margin with petroleum fuel, but higher sugar prices in 2007 eroded Brazilian ethanol's margin of competitiveness with petroleum products. Biofuel economics has its own built-in, self-limiting brakes. Taking ethanol from sugar cane as an example, as Brazil's ethanol production from sugar cane increases, the supply of sugar on international markets declines and thereby raises the price of sugar. The rising price of sugar will lead sugar cane to be redirected back into sugar production and away from ethanol. The supply response to soaring world sugar prices in late 2005–early 2006 is a good illustration. Likewise, as U.S. ethanol production from maize feedstock increases, the supply of maize in international markets eventually declines and raises the price of maize. Meanwhile, ethanol production from maize increases the supply of byproducts in the market, causing their prices to decline and hurting the overall margin received from ethanol production. These factors provide natural brakes on the economics of ethanol. Indeed, Ethanol Africa, which is planning South Africa's first commercial ethanol plant based on maize, in February 2007 said that high grain prices were making it difficult to raise funding for its plant (*Financial Times* 2007).

3.51 The margin of competitiveness for biofuels so far has been narrow. The small competitive margin has important implications for the tradability of ethanol, and explains why only a tenth of global biofuels produced and sold in the world are internationally traded, half of which is Brazilian ethanol (USDA 2006n). It is easy to show a large number of countries where local costs of biofuel production would be higher than import-parity prices for biofuels and for equivalent petroleum fuels. But it is difficult to find countries (Brazil being a recent exception) that are potential large exporters of ethanol or other biofuels.

3.52 Some countries suffer from exceptionally high insurance and freight costs for all goods including liquid fuels. Landlocked countries in Africa, Asia, and Latin America, for example, cannot have large sea-going tankers arriving at their borders. Besides the higher per-kilometer costs of shipping fuels by rail or road, they also face political problems and uncertainty posed by traversing other national jurisdictions. Even the countries on the coast of Africa face high insurance and freight charges because of low shipping volumes and irregular shipments, poor on-loading and off-loading infrastructure, and poor inland capacity for handling shipments. Even more prosperous Brazil has long suffered from poor port and inland transport infrastructure, further raising import-parity and lowering export-parity prices at inland markets (Espadas 1994). And emerging soybean producer and potential biodiesel competitor Argentina suffers similarly high "pre-FOB" costs (Nardi 2006).

3.53 The countries with high insurance and freight costs have in place one natural advantage for import substitution of biofuels (as discussed in respect of Figure 1.3 and Figure 1.4). The same factors suggest they are unlikely to be able to compete in biofuel exports—except with respect to adjacent land-locked countries. The unresolved issue is the extent to which these same high transport costs feed back into high costs for domestically produced biofuels—so high, in fact, as to overwhelm the seemingly high natural import protection afforded biofuels in that country.

3.54 In analyzing the impact of biofuel production and trade, it helps to distinguish between the issues of quantitative versus pricing effects. Some governments express hope that biofuels could develop into cheaper alternatives to petroleum fuels on a large scale. This is not likely for a long time. For the foreseeable future, biofuel production will remain a small fraction of the total petroleum fuel production and, as a result, biofuels largely will continue to be price takers in the market rather than drivers of transportation fuel prices. This means that average biofuel prices on a petroleum-equivalent basis will not be significantly lower than those of petroleum over the long run on the international market—particularly as countries try to force biofuel production to higher levels. As the production of biofuel feedstocks increase, the marginal cost of supply increases as well because of limitations of suitable lands and available water, among other causes. Given the existing stocks of land and the expected feedstock yields per hectare far into the future, the economic scale of production of biofuels will remain a small percentage of global transport fuel consumption for some time to come.

3.55 Biofuels may be price takers, but they may still be able to influence world petroleum prices if they can contribute to sufficient additional marginal supply. If biofuels could meet, for example, 3 percent of global gasoline and diesel fuel demand (after adjusting for fuel efficiency differences and incremental energy used in biofuel production)—or 1.5 percent by volume of total oil consumption—this would amount to about 1 million barrels per day of petroleum oil. While such substitution would not reduce world petroleum consumption in absolute terms, which has been growing at 1.6 percent annually during the last decade, it would moderate petroleum demand growth and petroleum price increases, everything else being equal.

3.56 An important remaining issue is that of security of supply of biofuels. Trade in biofuels will not develop as an alternative to trade in petroleum fuels if biofuel supply poses comparable insecurity issues to that of petroleum supply. Importing countries are concerned about such things as geographical distribution of exporting countries. If regions with low production costs are concentrated primarily in one or two countries, it may be difficult for biofuel trade to take off, even if the potential exporting countries have plentiful land suitable for biofuel production. For example, Japan, which is ill-suited for biofuel production and is interested in biofuels for their GHG emission reduction benefits, worries that, at present, Brazil is the only obvious large exporter, and views reliance on one exporting country as potentially compromising security of supply.

3.57 The effects of biofuel trade liberalization are closely linked to the economics of biofuel production relative to petroleum prices and to the related overall size of the biofuel market in the future. In the short run, trade liberalization would enable a few low-cost producers to expand their market share, while high-cost producers that currently are given preferential trade agreements (for example, CBI countries) could lose their market share entirely. This could help reduce overall subsidies provided to biofuels, increasing welfare globally. Given current economics of biofuels and consumption of transportation fuels, the two most important countries in terms of trade potential are the United States (as a potential importer) and Brazil (as a potential exporter). Thus, these two countries have been subjects of the few biofuel trade liberalization studies that have been completed to date. The existing studies are surveyed in the following section, after which biofuel issues facing WTO will be summarized in the final section of chapter 3.

Potential Impact of Biofuel Market Growth and Trade Liberalization

3.58 There are few studies examining the effect of biofuel trade liberalization. Two recently published papers investigated the impact of liberalizing ethanol trade between Brazil and the United States. The findings of the two studies showed some differences, but both pointed to increasing trade between the two countries following liberalization. This section also reviews studies investigating the implications of increasing the global and local biofuel markets for land requirements and prices of biofuels and their feedstocks.

3.59 The first study found that removal of the U.S. import tariffs on ethanol from Brazil would reduce ethanol production in the United States, reduce ethanol consumption in Brazil and increase its consumption in the United States, increase ethanol exports from Brazil to the United States, lower ethanol prices in the United States, and raise world ethanol prices. Predictably, it would also eliminate ethanol trade between the Caribbean and the United States through the CBI (Elobeid and Tokgoz 2006). In the first scenario, the study assumed that the U.S. government's domestic biofuel policy would stay in place, including the federal tax credit of US$0.51 per gallon, but that the specific import tariff of US$0.54 per gallon would be eliminated (but all other support measures would stay in place). Between 2006 and 2015, elimination of the tariff results, on average, in an increase of 24 percent in world ethanol prices, an increase of 1.8 percent in world sugar prices, and a decline of 1.5 percent in world maize prices (because less maize in the United States is diverted to the ethanol market). In the United States, ethanol production declines by 7 percent but consumption increases by 4 percent. Net imports triple, and domestic ethanol prices fall by 14 percent. In Brazil, ethanol production increases by 9 percent but domestic consumption falls by 3 percent, and net exports rise by 64 percent. In the second scenario, the study assumed that the federal tax credit of US$0.51 per gallon would be eliminated in addition to the removal of import tariffs. In that case, U.S.

consumption of both ethanol and gasoline would fall relative to the base case (which has both the import tariffs and tax credit for ethanol blenders in place). U.S. ethanol prices; world ethanol, sugar, and maize prices; Brazilian ethanol production; and net Brazilian exports of ethanol would all be lower than in the first scenario.

3.60 The second study focused on a comparison of sugar-ethanol processing in Brazil with the U.S. maize-ethanol industry. A time-series analysis of data for the last 30 years, including historical market prices and exchange rates, was carried out to compare dry mills, wet mills, and distilleries. The study also examined the possibility of dry mills using high-starch maize—which was found to reduce ethanol production costs by nearly US$0.03 per liter—and the benefits and costs of cogeneration of biomass power—which would reduce ethanol production costs by a further US$0.02 per liter. The study compared the processing-cost effects of changing commodity prices and exchange rates with today's technology[16] with a view to assessing the direction of trade in the absence of tariffs on ethanol. The study found that there was no trend in cost advantage between ethanol from maize in the United States and ethanol from sugar in Brazil, but there would be seasonal patterns of advantage. These periods of advantage would last several years. Ethanol from sugar cane was favored half the time. The study also computed the breakeven price of petroleum oil above which E85 used in vehicles optimized for E85 with a fuel economy penalty of 15 percent would be competitive. It found that the breakeven price was US$35 per barrel of oil in 2000, rose to US$55 per barrel when maize prices rose to US$3.40 per bushel in the spring of 2004, and returned to US$40 per barrel after maize prices fell later in 2004 (Gallagher et al. 2006).

3.61 Another study examined the impact in 2010 on the world sugar and ethanol markets posed by Brazil's requiring blending of 8 percent ethanol in diesel fuel beginning in 2006. World ethanol prices rise by 0.9 percent and sugar prices rise by 3.5 percent. In Brazil, ethanol consumption increases by 16 percent, ethanol exports fall by 3 percent, sugar exports fall by 2.9 percent, ethanol prices rise by 4.7 percent, and sugar prices rise by 5.5 percent (Koizumi and Yanagishima 2005).

3.62 To gain an understanding of how the world oilseeds market might be affected by growth in demand for biofuel, a 2003 study examined one effect of an initial increase in demand for vegetable oils (LMC International 2003). The study considered soy, rapeseed, sunflower, and palm oils, and assumed that they were, for the purpose of the study, entirely substitutable. The study used historical supply and demand elasticities with respect to price for oils as well as byproducts to arrive at the equilibrium response. The oilseed's world average extraction rates for meal and oil differ considerably (see Table 3.1). These differences have a large impact on oilseed producers.

[16] The study assumed an ethanol yield of 2.8 gallons of ethanol per bushel of maize, which is current, but 76.1 liters per tonne of sugar cane, against the yield of 79.4 liters of anhydrous ethanol per tonne of sugar cane in the 2004–05 crop season in Brazil.

Table 3.1 Worldwide Average Extraction Rates by Weight
(Percent)

Oilseed	*Meal*	*Oil*
Soybeans	78	18
Rapeseed	60	39
Sunflower	47	41
Palm	10	90

Source: LMC International (2003)

3.63 The study found that vegetable oil prices increased but meal prices declined because of surplus production. An interesting finding, consistent with the extraction rates shown in Table 3.1, is that, for an increase of 5.8 percent in the price of vegetable oil, palm growers receive 5.0 percent more but soybean growers receive only 0.8 percent more. The study assumed that the net income of an oilseed grower was the volume-weighted average of the increase in the price of vegetable oil and the decrease in the price of meal. Because soybean growers produce much more meal relative to oil than other oilseed growers, their earnings increase the least. This finding would suggest that, for the purpose of aiding farmers, mounting a biofuel program based on soybeans would be much less efficient than that for other oilseed growers with higher oil extraction rates.

3.64 The Energy Information Administration (EIA) of the U.S. Department of Energy carried out a study analyzing the near- and mid-term potential price and supply effects of the Fuels Security Act of 2005, which was similar in content to the 2005 Energy Bill. The average price increase for gasoline between 2006 and 2025 resulting from adopting the Fuels Security Act of 2005 was calculated to be 0.8 U.S. cents per gallon (0.2 US cents per liter). The ethanol content in gasoline would rise and peak at 5 percent in 2012, after which it would fall because of increasing use of cellulosic bioethanol, which receives extra credit (U.S. EIA 2005) (see annex 3 for how cellulosic ethanol is treated in the 2005 Energy Bill).

3.65 A study by LMC International conducted in 2006 examined the impact of substituting biofuels for 5 percent of gasoline and diesel fuel demand worldwide by 2015 (LMC International 2006). The study, which took fuel economy differences into account, first examined whether biofuel production has had effects on crop prices. An analysis of correlations between monthly world prices of feedstocks for biofuels and Brent crude oil between 1994 and 2006 found that prices of sugar and molasses were highly correlated with those of Brent, with a correlation coefficient of 80 percent and more than 90 percent, respectively. The study suggested that a share of 10 percent of global demand derived from biofuel might be the threshold above which a positive association between fuel and commodity prices starts to emerge—ethanol in 2005 accounted for about 15 percent of world sugar cane demand and for about 45 percent of world molasses demand. This would suggest that the decision by Indonesia and Malaysia to set aside 40 percent of their total palm oil production for biodiesel would be expected to lead to a strong link between palm oil and crude oil prices. Conversely, palm oil analysts in January 2007 speculated that falling petroleum crude oil prices might exert downward pressure on palm oil prices, in part by casting doubts on the feasibility of biodiesel, after the "psychological level" of US$60 a barrel was broken in futures trading (Dow Jones Commodities Service 2007a).

3.66 In examining the prospects of blending 5 percent biofuels, the LMC study analyzed several scenarios for additional supply to meet this goal:

(1) Sugar cane produced in the Center-South region of Brazil alone will supply the required additional amount for ethanol.

(2) Sugar cane worldwide will supply the required additional ethanol.

(3) Sugar cane worldwide will supply 50 percent, and maize worldwide will supply 50 percent, of the required additional ethanol.

(4) Carbohydrates (maize, wheat, barley, cassava, sugar cane, and sugar beets) worldwide will supply the required additional ethanol.

(5) Palm oil produced in Indonesia alone will supply the required additional biodiesel.

(6) Palm oil worldwide will supply the required additional biodiesel.

(7) Oilseeds (rapeseed, soybean, palm, and sunflower oil) worldwide will supply the required additional biodiesel.

3.67 The study showed that if the entire world supply of carbohydrates were converted to ethanol today, the maximum potential share of ethanol in gasoline would be only 40 percent. For oilseeds, even a 10 percent blend of biodiesel with petroleum diesel would not be achievable. To achieve a 5 percent blend, the study found that, in terms of additional hectares required, by far the most efficient pathways were sugar cane to ethanol in the Center-South region of Brazil and palm oil to biodiesel (see Table 3.2). Using carbohydrates and oilseeds worldwide to make the two biofuels would require an additional 100 million hectares of land, or an increase of more than 15 percent. The amount of land required to make biodiesel from palm oil around the world is only marginally greater than that required for biodiesel from palm oil in Indonesia. The figures for biodiesel illustrate the high biodiesel yield per hectare of land when using palm oil compared with other oilseeds. In practice, relying only on Brazil and Indonesia would result in major inroads into grazing areas in Brazil, pushing ranches further into the cerrado—the country's vast tropical savanna ecoregion—and to large-scale encroachment on tropical rainforest areas of Kalimantan in Indonesia, with potentially significant effects on biodiversity as well as net changes in GHG emissions.

3.68 The above study did not give consideration to the water implications of area expansion. If Brazilian sugar cane and Southeast Asian oil palm are chosen to meet global biofuel needs, then there will be little or no additional demand for irrigation water. If feedstocks are grown around the world, a greater area of land than that indicated in Table 3.2 may be required.

Table 3.2 Land Required for Biofuel Production (million hectares)

Biofuel	*Feedstock*	*Location*	*Baseline*	*5% blend*	*Difference*
Ethanol	Sugar cane	Brazil Center South	8	17	10
Ethanol	Sugar cane	World	22	38	16
Ethanol	Cane/maize	World	178	207	29
Ethanol	Carbohydrates	World	448	498	50
Biodiesel	Palm oil	Indonesia	9	20	10.5
Biodiesel	Palm oil	World	20	32	11.3
Biodiesel	Oilseeds	World	208	258	50

Source: LMC International 2006.

WTO Issues for Biofuels

3.69 Chapter 2 and the description of biofuel policies in this chapter show that industrial countries are in a position to provide greater subsidies to domestic biofuel producers—both for the production of the feedstocks and for the manufacture of biofuels themselves—than developing countries. This has created a large domestic biofuel industry that may not be able to compete with imports of petroleum fuels and biofuels, necessitating high tariffs on the latter while providing tax reductions on the domestic market. If the current policies continue, this may adversely affect developing countries that have comparative advantage in biofuel production and export.

3.70 As explained in chapter 2, removing border restrictions yields considerable welfare gains. For biofuels, maximum applied ad valorem tariffs for harmonized system (HS) 2207.10 (undenatured ethanol) and HS 2207.20 (denatured ethanol) have earlier been reported by Steenblik (2005c) as 300 and 125 percent, respectively, against 30 percent for HS 3824.90 (biodiesel). Specific tariffs for biodiesel can be higher than 30 percent of the border value when converted to an ad valorem tariff equivalent, as the discussion of Australia in annex 3 shows.

3.71 Agricultural goods tend to enjoy greater protection than industrial goods. Importantly, once a good is afforded protection, it is easier to prevent reform if the good is classified as an agricultural commodity and trade negotiations fall under the Agreement on Agriculture. Ethanol, but not biodiesel, falls under the Agreement. Ethanol is included in the WCO's HS chapter 22, and annex 1 to the Agreement on Agriculture states that HS chapters 1 through 24 are covered by the Agreement. Biodiesel, on the other hand, falls under chapter 38 which is excluded from consideration under the Agreement. The rationale for classifying ethanol under agriculture is that, undenatured, it can be imbibed. Support given to biodiesel manufacture may fall under governments' commitments under the Agreement on Agriculture if the subsidies can be shown to reach the farmer directly. One example is if the biodiesel manufacturer is required to offer a minimum guaranteed price to the farmer. Indirect benefits to agriculture as a result of increased demand for biodiesel—from such government interventions as biodiesel mandates or fuel-excise-tax exemptions—are not considered agricultural subsidies. Although ethanol is classified as an agricultural good, it remains to be seen how subsidies provided for ethanol production will be notified to the WTO (that is, as agricultural subsidies or non-agricultural subsidies).

3.72 To increase market access more rapidly, some have proposed that ethanol be reclassified as an industrial good or an environmental good. The latter is a relatively new concept that is still being formulated, and is unlikely to affect market access for ethanol in the near to medium term. But because this proposal has received some attention, it is covered in some detail in annex 1. The Doha Ministerial Declaration of 2001 specifically referred to environmental goods and services as an area that could be targeted for faster liberalization. The Declaration also had a paragraph on the desirability of increasing market access for non-agricultural products, highlighting products of export interest to developing countries—which biofuels could very well be.

3.73 In practice, reclassification is unlikely to have near-term policy consequences. The WCO's Council considers amendments in four-year cycles. The most recently completed review occurred in June 2004 and the amendments will be implemented on January 1, 2007. Amendments under the next review cycle are not scheduled for implementation until 2012 (Steenblik 2005b). As such, waiting for reclassification with a view to fastening the pace of liberalization does not seem practical in the near term. More importantly, reclassification is not a requirement for liberalizing market access: being classified as an agricultural product does not bind the good to high tariff rates, nor is reclassification necessary to take a good out of annex 1 of the Agreement on Agriculture (which spells out which products are included under the Agreement). That said, classifying ethanol as an agricultural good does enable governments to protect domestic producers longer, and, in the extreme, declare ethanol a sensitive or special product (see annex 1) to shield it further from external pressure for liberalization.

3.74 One policy question falling under the rubric of environmental goods is whether distinctions should be made on the basis of process and production methods. Such distinction would make administration more complex, but there is already growing pressure and interest in examining the environmental impact of individual crop and crop-based energy production pathways. Although not related to WTO negotiations, the Dutch government's statement that palm oil will likely be excluded from future subsidies for renewable projects and the soybean traders' moratorium on the purchase of soybeans grown on newly cleared rainforests in Brazil, mentioned earlier in this chapter, are indicative of this growing trend.

3.75 Article III, National Treatment on Internal Taxation and Regulation, in GATT 1947, states that "internal taxes and other internal charges, and laws, regulations and requirements affecting the internal sale, offering for sale, purchase, transportation, distribution or use of products, and internal quantitative regulations requiring the mixture, processing or use of products in specified amounts or proportions, should not be applied to imported or domestic products so as to afford protection to domestic production." Article 3 of the Agreement on Subsidies and Countervailing Measures prohibits "subsidies contingent, whether solely or as one of several other conditions, upon the use of domestic over imported goods," including production subsidies contingent on use of domestically grown feedstocks (WTO 2006). These principles ensure equal treatment of biofuels and their feedstocks from around the world on any given domestic market.

3.76 Although they have not been challenged under WTO commitments, some subsidies and mandates are reserved explicitly for in-state production. For example, the provincial government of Manitoba in Canada provides a reduction in the gasoline tax of C$0.025 per liter for gasohol containing a 10 percent blend of ethanol produced and sold in Manitoba, and exempts biodiesel produced in the province from both the retail sales tax and the automotive fuel tax (Manitoba Government 2003 and 2006). More recently, the Louisiana State Legislature in the United States in June 2006 passed a bill that requires 2 percent by volume of the total gasoline sold in the state to be ethanol from domestically grown feedstock or other biomass once a certain domestic ethanol production target is reached (Louisiana State Legislature 2006). Interestingly, the U.S. Supreme Court ruled in 1988 that tax credits given only to in-state manufactured ethanol violated the Commerce Clause of the Federal Constitution. More specifically, the case heard by the Supreme Court involved a challenge mounted by an Indiana firm against an Ohio statute giving a tax credit against the Ohio motor vehicle fuel sales tax for each gallon of ethanol sold (as a component of gasohol) by fuel dealers, but only if the ethanol was produced in Ohio or, if produced in another state, to the extent that the state granted similar tax advantages to ethanol produced in Ohio. At the time, Indiana had no ethanol tax exemption, and hence the ethanol produced in Indiana was not eligible for the Ohio tax credit (FindLaw undated).

3.77 Aside from possibly a handful of exceptions such as those discussed in the preceding paragraph, fuel-tax reduction and exemption, an instrument of nearly all governments implementing biofuel programs, are not trade-distorting because they do not discriminate on the basis of origin. The fiscal instruments that can be used within the bounds of WTO rules to protect domestic producers are import tariffs. Import tariffs are also the easiest policy instrument to employ because, unlike other forms of support, they do not require a budgetary allocation. Fuel tax reduction and exemption may have to be debated by the parliament because they will entail a loss of government revenue. Imposing high import tariffs, by contrast, may not entail any budgetary loss. Because they are not subject to budgetary debate and scrutiny, high tariffs, which distort trade significantly, tend to be readily imposed for goods that governments wish to protect.

3.78 One question in the context of the Agreement on Agriculture is whether the current agricultural support for biofuels or their feedstocks belongs to the amber box (support in need of reduction), or the green box under which the subsidies are minimally or non-trade distorting and can be maintained and even increased without restrictions. To be eligible for green-box payments, certain criteria must be met. Under all circumstances, subsidies must be publicly funded, not involve transfers from consumers, and not have the effect of providing price support to producers. In addition, the government support must meet specific policy criteria, the relevant one of which for biofuels is described in paragraph 12 in annex 2 to the Agreement on Agriculture. That paragraph covers payments under environmental programs. Payments must be part of a clearly defined government environmental or conservation program and must fulfill specific conditions, including those related to production methods or inputs. Payments must be limited to the extra costs or loss of income arising from compliance with the program (WTO 2006).

3.79 It seems difficult to regard subsidies given to promote biofuel production as offsetting the extra cost or loss of income involved in complying with an environmental program. Indeed, the U.S. government does not consider that Bioenergy Program by the Commodity Credit Corporation (see paragraph A3.22) met any of the policy-specific criteria in the green box. Quoting paragraph 7 in annex 3, which states that "measures directed at agricultural processors shall be included [in the Aggregate Measure of Support] to the extent that such measures benefit the producers of the basic agricultural products," the Department of Agriculture suggest that the Bioenergy Program could be viewed as an amber box subsidy (USDA 2006l). This statement also suggests that subsidies for ethanol production are regarded as agricultural subsidies by the USDA.

3.80 Trade in biodiesel is extremely small at present. There are no large tariff barriers in major current and future biodiesel consumers and potential importers, including the United States and the European Union which levy high tariffs on ethanol. Arguably the greatest impediment to biodiesel trade in the coming years could be technical barriers to trade in the form of certification for environmental sustainability.

3.81 Another policy area in trade falls under technical barriers to trade. Fuel specifications can constitute such barriers. In December 2001, the American Society of Testing and Materials (ASTM) issued a specification (D 6751) for biodiesel fuel, to be used in a blend with petroleum diesel. Biodiesel defined by ASTM D6751 is registered with the U.S. EPA as a fuel and a fuel additive. Major engine companies operating in the United States have adopted D6751 for warranty purposes. German authorities issued a provisional specification for fatty acid methyl ester under DIN 51606. In 2003, DIN 51606 was replaced by EN 14214 of Europe's Committee for Standardization upon its publication, for biodiesel to be used pure as well as in a blend. The European specifications have more stringent limits for sulfur and water. The iodine number in EN 14214 effectively excludes pure biodiesel derived from soybean oil or sunflower oil, but Spain has raised the limit for the iodine number to permit greater use of soy-derived as well as domestic sunflower-derived biodiesel. Additional work is needed for wider application of the EN 14214 specifications and associated test methods. For example, test method EN 14103 for determining the ester content required by EN 14214 is not applicable if the carbon number is 14 or lower. This means that the test cannot be used for biodiesel derived from coconut oil or palm oil (JPEC 2005).

3.82 The European fuel specifications currently allow blending of up to 5 percent ethanol and 15 percent ethers (oxygen-containing organic compounds for which ethanol is one possible feedstock) in gasoline, and up to 5 percent biodiesel in petroleum diesel. As mentioned earlier, raising these limits is currently under consideration to expand the use of biofuels. In the United States, blending 10 percent ethanol in gasoline is common. The U.S. EPA has said that it would consider E20 to be a new fuel, and the state of Minnesota would need to obtain an EPA waiver before implementing its E20 mandate in 2013 (see annex 3) (NMMA 2006). As in Europe, blending biodiesel up to 5 percent is considered permissible.

3.83 Technical barriers to trade are likely to be more important for biodiesel than ethanol. Unlike ethanol, biodiesel is a mixture of different size molecules with varying levels of unsaturation. The composition of a given biodiesel fuel, and the molecular structure of each ester comprising the fuel, depends on the feedstock (and the process conditions to a lesser extent); the amounts of contaminants left in the biodiesel fuel depend on the production process. It is relatively easy to make biodiesel, but it is difficult to make on-spec biodiesel. Ensuring fuel quality consistency presents a much greater challenge for biodiesel than ethanol, especially for biodiesel made at small-scale, simple-technology facilities. The European Union has historically channeled efforts to establishing biodiesel standards based on data obtained from biodiesel made from rapeseed oil, whereas the United States has concentrated on biodiesel from soybean oil. Biodiesel from rapeseed is more suited to the European climate from the point of view of wax formation at low temperature, although biodiesel from other vegetable oils such as soybeans and palm can be mixed with rapeseed diesel at low percentages without causing vehicle performance problems. The existing specifications and test methods are considered insufficient for protecting advanced engines used to meet the most stringent emission standards in industrial countries. For this reason, the world’s major auto manufacturers, in their most recent proposed revision for the World Wide Fuel Charter in August 2005, continue to recommend against permitting biodiesel in the most advanced fuel specification category (Methanol Institute and International Fuel Quality Center 2006). More work is needed for developing test methods and specifications that are applicable to a larger pool of biodiesel fuels made from a variety of feedstocks and for ensuring compatibility with modern diesel engines.

4

Conclusions

4.1 Interest in biofuel trade liberalization is driven by a more general interest around much of the world in the potential for biofuels to substitute for petroleum products in transportation applications. As chapter 1 pointed out, this more general interest targets three primary objectives:

- Concerns about energy security arising from increasing world petroleum prices and the prospect of eventual depletion of petroleum
- Environmental considerations that motivate governments to seek ways of curbing rising GHG emissions overall and especially from the transport sector, and, to a lesser extent, reducing emissions of harmful pollutants from the tailpipe
- A desire to support domestic agriculture against the backdrop of international trade negotiations to liberalize agricultural trade.

Although the above three objectives are not shared equally by all countries, together they explain much of the motivation for the biofuel policies that were overviewed in chapter 3. These objectives for biofuels interact with agricultural production and policy issues (discussed in chapter 2). Chapter 4 will first address the above three objectives before turning to implications for biofuel trade policy.

4.2 The first objective may call for diversity of supply, and, in particular, identifying energy suppliers other than major petroleum oil exporters. In nearly all countries, the objective of increasing energy security has been more narrowly focused and is synonymous with independence from imported energy and with self-sufficiency; this excludes trade as an alternative for meeting the above broader objective. Previous chapters showed that biofuels are likely to play only a small role in volumetric terms in replacing petroleum fuels in transportation on a global basis in the foreseeable future. Present and projected input-output relationships between the land, water, and other resources available globally suggest substitution for petroleum transportation fuels on the order of a few percentage points. Given projected growth in demand for transportation fuels, this level of substitution will not reduce overall petroleum fuel consumption below current levels but, rather, will moderate the growth in demand for those fuels.

4.3 It helps to differentiate between volumetric effects on self-sufficiency versus those on future petroleum price increases. In this latter sense, biofuel production provides some potential for helping ameliorate future price increases for petroleum and its products. Given the tight supply situation that has led to large price increases since 2004 on the world petroleum market, an even marginal increase in supply would be expected to lower fuel prices. While this potential for relative impact on price increases is worth mentioning, it does not suggest that petroleum prices will not continue to remain high or even increase into the future as overall global demand continues to grow.

4.4 Nevertheless, some countries see biofuels as a way to secure cheaper fuels. Indonesia, for example, aims to substitute biodiesel for 10 percent of petroleum diesel with a view to reducing or eliminating the diesel price subsidy. The basis for this approach seems questionable. First, biofuels have historically required, and for the foreseeable future continue to require, significant subsidies. As such, it is difficult to see how biofuels can help reduce fuel price subsidies. Second, biofuels are nearly perfect substitutes for petroleum fuels and require essentially no additional infrastructure or infrastructure modification for transport and distribution (with the exception of pipeline transport and blending of ethanol). Under these circumstances, it would be difficult to maintain a sizable price difference between biofuels and petroleum fuels for long, except in landlocked or isolated areas or very small economies; in an open market, prices of biofuels and petroleum fuels would equilibrate after allowing for transportation and quality and fuel-economy differences. Third, growing demand for biofuels exerts upward pressure on feedstock prices—as recent world price movements of maize and palm oil have shown—again making it difficult to maintain sizable price differences with petroleum products in favor of biofuels.

4.5 In terms of national prospects for meeting the more narrowly defined self-sufficiency objective, biofuel production is likely to make only a small contribution in most countries. Brazil recently passed the self-sufficiency margin by combining domestic petroleum production with ethanol production. But Brazil is exceptionally well endowed for the purpose of ethanol production, and few countries can match Brazil's natural endowments. Indonesia has substantial potential to be a major supplier of biodiesel from palm oil, but its domestic policies underprice transport fuels in the domestic market and work against the objective of self-sufficiency. There are also serious environmental concerns about expansion of palm plantation in Indonesia. As for countries with limited or no petroleum production potential, chances of achieving self-sufficiency in transportation fuels from investing in biofuel production are highly unlikely. Most petroleum-importing countries will be left with the option of importing biofuels from what is expected, in the near term, to be a small number of exporters of relatively small volumes of biofuel (with Brazil's current ethanol export prospects being a possible exception). A combination of policies to reduce petroleum consumption should be implemented together with policies for biofuels to achieve the objective of reducing dependence on imported energy. Policies to reduce energy consumption should include sending correct market signals to consumers by reflecting international fuel prices, incentives for energy efficiency improvement, and demand management.

4.6 The environmental objective that provides part of the interest in biofuel production and consumption also confronts issues related to agricultural policy, to choice of feedstock crops by different countries, and to limitations in feedstock production capacities within existing agricultural operations. Biofuels are renewable on paper, but their potential for reducing lifecycle GHG emissions varies markedly from case to case, as illustrated by Table 1.1 and Table 1.2. There are also local environmental effects associated with biofuel production and use that can be, but are not always, positive. As such, the environmental benefits of biofuels should not be assumed but need to be examined on an individual basis.

4.7 Studies indicate that some feedstock and ethanol production pathways provide net environmental benefits. An example, if there is no change in land use, is ethanol produced from sugar cane in Brazil, especially when net GHG impacts are accounted for. But others—such as ethanol produced from sugar cane under irrigated conditions in water-scarce India—would have lower environmental benefits. Water is going to be an increasingly scarce resource due to competition from urban areas and, in many places, due to climate variability. In most countries, water is not valued like energy. Where water is projected to become increasingly scarce, including in parts of Africa, water shortages may become a serious constraint on biofuel production and should be carefully examined. Similarly, ethanol from maize in the United States—to the extent that it would come from increased maize production rather than from decreased U.S. maize exports—could increase the size and intensity of the "dead zone" in the Gulf of Mexico that is attributed to agricultural runoff (fertilizer and pesticides) from maize farms. And any ethanol production in the United States from maize is acknowledged to have much smaller benefits in the reduction of lifecycle GHG emission compared with ethanol from sugar cane in Brazil; it could even result in a net increase in GHG emission if electricity from coal is used. For that matter, the European Commission questions if there will be benefits in the reduction of GHG emission from additional ethanol production in Brazil if cane areas are expanded by clearing virgin savanna. Likewise, biodiesel produced from tropical plant oils that come from expanding palm oil plantations into rainforests, notably in Indonesia, raises serious questions about the loss of biodiversity and potential benefits regarding lifecycle GHG emission. Two studies report that, when CO_2 emissions from burning peat land (in part to expand palm oil plantation) and other forest fires are included, Indonesia becomes the world's third largest emitter of CO_2 after the United States and the Republic of China, up from twenty-first when these emissions are not considered (*Wall Street Journal* 2006, *Energy Economist* 2007). The two-year moratorium by soybean traders on the purchase of soybeans from newly cleared rainforests in Brazil may foreshadow the impact of environmental concerns on world agricultural and biofuel markets. Global environment benefits such as net GHG reductions need to be verified for each feedstock, production pathway, and location, and there can also be negative environmental effects occurring at regional, national, and local levels from the feedstock production process that should not be ignored. These considerations raise questions about classifying all bioethanol and biodiesel as environmental goods.

4.8 A careful consideration of environmental effects is particularly important to level the playing field. High petroleum oil prices are spurring not only efforts at making biofuels commercially viable—the most significant and potentially promising being pursuing technical breakthroughs to dramatically reduce costs of second-generation biofuel production. The same high oil prices are also driving investments and R&D

efforts toward the production of other liquid fuels, such as coal to liquids, gas to liquids, oil from tar sands, and shale oil. Most of these alternative liquid fuels are economic and commercially viable at US$60 per barrel of crude oil, but uncertainties about future oil prices have kept commercial development in check. Production of liquid fuels from tar sands and shale oil has large and adverse ecological consequences, both local and global. For example, if tar sands are included, Canada may even be home to the world's largest petroleum reserves, but tar sands lie under Canada's boreal forests. Tar sand production entails strip mining, and extracting oil is extremely energy and water-intensive, requiring 2 to 5 liters of water for every liter of oil and leaving vast quantities of contaminated tailings. According to the figures released by the government of Canada, if tar sands output reaches more than 3 million barrels a day by 2015, Canada's GHG emissions could double between 2004 and 2015 (*Petroleum Economist* 2006). But in the absence of properly accounting for these environmental externalities, tar sands may look attractive and production costs could be lower than those for biofuels.

4.9 The foregoing discussions highlight interactions among different economic forces, and also between the energy-security and environmental objectives outlined above. High oil prices offer the potential to commercialize a range of alternative energy sources, not just biofuels. The "benchmark" price may shift over the medium to long term as these alternative energy sources are developed on a large scale. For example, Canada plans to triple oil production from tar sands in the next 10–15 years, adding another 2 million barrels of oil a day to the supply chain. Environmental concerns are having increasing effects on commercial production, driving R&D efforts at environmental sustainability of production methods for all energy sources. The pace of technological breakthroughs—both for cost of production and for environmental sustainability of production methods—and hence the relative commercial viability of different substitutes for conventional petroleum oil is difficult to forecast a decade or two into the future. As a general observation, diversifying supply can help hedge against escalating oil prices. Experience suggests that an efficient way to promote supply diversification is to establish and enforce a clear, stable, and transparent regulatory framework including environmental regulations; establish hard sun-set clauses for financial assistance and other protection measures (such as import tariffs) provided by government so that an "infant industry" does not remain in its infancy for decades to come; and properly account for environmental externalities through fiscal and other means.

4.10 As regards the third objective, some have argued that biofuel production objectives amount largely to disguised support for domestic farmers. National biofuel agendas indeed provide appreciable scope for increasing the demand for a number of agricultural commodities (maize and sugar, in particular) that are recipients of large subsidies in a number of countries. With feedstocks constituting more than half the production costs for biofuels, the link between biofuels policy and agricultural policy (and, increasingly, the links between petroleum prices and agricultural prices) cannot be ignored in discussing biofuel policy.

4.11 These same links bring into further question the arguments from some quarters that subsidies for biofuel production should be considered green box environmental payments within the WTO. If government expenditures were being made to compensate farmers and ethanol producers for costs borne directly in support of otherwise-uncompensated environmental improvements (such as soil erosion prevention), then the green box argument could hold some sway. However, as discussed in chapter 3, this is not the case with any of the feedstocks receiving current government support. The preceding discussion on the environmental impact of biofuels also cautions that environmental benefits of biofuels cannot always be assumed. Lastly, large producer subsidies for biofuels are likely to be provided predominantly in industrial countries, and permitting their continuation would discriminate against developing countries which are not in a budgetary position to offer them, while slowing down trade reform negotiations and entrenching protection.

4.12 It is also worth noting that there are circumstances in which energy security and environmental concerns can be better addressed by other forms of bioenergy. Some, such as biomass for heat and electricity generation, have been demonstrated to be commercially viable without subsidies. Biofuels appear to be attracting more attention at the moment—perhaps reflecting the biofuel policy developments in the United States and the European Union—but it is important to view biofuels in a broader context that encompasses all forms of bioenergy. It may be that, in many developing country circumstances, it would be more productive to channel efforts at developing other forms of bioenergy than liquid biofuels.

4.13 From the foregoing, what answers does the present study provide for the questions posed in chapter 1?

- What border and domestic distortions protect biofuel manufacturers, including feedstock growers, today?
- How would biofuel trade be affected by agricultural reform?
- How would removing restrictions on international trade of biofuels affect the global biofuel industry and other commodity prices?
- What are the policy lessons from the analysis?

4.14 This report outlined a broad array of measures supporting biofeedstock and biofuel production, including fuel-tax reduction or exemption, mandatory blending, high import tariffs, government purchase policy for biofuels, production subsidies, investment subsidies, and financial incentive programs for users of biofuels such as lower taxes on vehicles designed for biofuels. Industrial countries have the greater capacity to apply policies that constitute either budget expenditures or public revenue reductions than developing countries. As a result, industrial countries tend to be better positioned to use policy interventions to affect the supply and demand for biofuels. This distinction is made important by the economics of biofuel production, whereby no biofuel pathway and product combination provides a low-risk and profitable investment without government fiscal support of some kind at this point in time.

4.15 Only a handful of developing countries would be in a position to provide the magnitude of tax exemptions granted in the European Union, not least because many developing countries levy low fuel taxes, especially on diesel. In granting tax exemptions, the European Union has publicly stated a principle of not over-compensating biofuel producers and applying it during the latter half of 2006. Other countries grant tax exemptions even in times of favorable biofuel economics (as in the United States in the summer of 2006). Certain tax differences may be justified to capture poorly-accounted-for environmental externalities, but even where such externalities exist, they are much smaller than the tax reductions typically offered. At the least, consideration should be given to moving away from a fixed subsidy to a sliding scale subsidy that changes with a measure of profitability.

4.16 More generally, in setting tax rates on fuels, many factors need to be considered. Taxes on transport fuels typically seek to satisfy multiple objectives, including:

- Raising government revenue for general (nontransport) expenditure purposes
- Efficiently allocating resources to and within the transport sector
- Financing road provision and maintenance
- Reducing congestion
- Reducing the environmental externalities of road transport
- Redistributing income.

Correcting for environmental externalities is but one of the several objectives of fuel taxation. As such, there is no reason to waive fuel taxation altogether. The challenge of meeting the various objectives is especially difficult in low-income countries, where fewer policy instruments are available. Tax rates on goods that have external costs should be adjusted upward to reduce their consumption to a social optimum. Environmental externalities should be corrected for by taxing polluting goods, not by subsidizing nonpolluting alternatives (see Gwilliam et al. 2001).

4.17 Among types of government support given to biofuels, one seems appropriate. A legitimate role of government is to fund R&D for activities that, because of their public good characteristics, are more likely to be undertaken if centrally financed.[1] Although the private sector can and should be encouraged to undertake such work, research on emerging biofuel technologies that can dramatically expand supply or reduce costs seems an appropriate area for governments to support. In developing countries, R&D could focus on technologies—for primary feedstock production, processing of biofuels, or equipment modifications for alternative uses (such as direct use of plant oils in stationary sources in remote areas with no electricity supply)—that are particularly suitable in their context. An analysis of U.S. government subsidies for biofuels found that only a small fraction was for funding R&D (Koplow 2006), and similar findings are reported for the European Union (Kutas and Lindberg forthcoming).

4.18 Financial returns to biofuel manufacture are very much affected by feedstock and byproduct prices, which themselves are largely determined by agricultural policy regimes. A new and emerging trend, as discussed in chapter 3, is that, when the

[1] Publications that address issues related to public and private R&D policies in agriculture include Byerlee and Echeverria (2002), Roseboom (2003), and Evenson (2001).

amount of a given feedstock used for biofuel manufacture exceeds a certain threshold, its market price becomes increasingly affected by world oil prices. Excluding feedstock costs, conversion of sugar cane to ethanol is the least-cost route because sugar cane immediately yields six-carbon sugars that can be fermented into ethanol, and cane crushing leaves bagasse, which can be used to generate heat and power; but studies have shown that policy reforms affecting sugar will increase world sugar prices. By the same token, the limited studies of biofuel trade reform that have been carried out point to increasing world prices of both biofuels and crops used in their production following tariff removal, provided mandates, consumption subsidies, or both remain. These increases would reduce the economic attractiveness of biofuel use. For example, there have been many announcements targeting palm oil in Asia. In particular, a joint announcement by Malaysia and Indonesia committing what amounts to 40 percent of palm oil production to biodiesel has made analysts fear that palm oil prices could rise above soybean oil prices and in fact make palm oil too expensive for both fuel and food. A similar reversal of vegetable oil price relationships has already occurred in Europe, making rapeseed oil considerably more expensive than sunflower oil in recent years. Second-order effects (examining the impact of increased demand for a particular feedstock on the prices of byproducts and other crops that are substitutes), the combined effect of agricultural and biofuel trade reform together, and links to the world petroleum market have not been modeled in any detail. Doing so would give a better understanding of the likely consequences of greater biofuel production and greater trade.

4.19 The fuel ethanol market is much larger than that for biodiesel and has been the subject of more research on the impact of policy change. Biodiesel has been less economical to produce. Much of the biodiesel production in Europe has arisen from EU policy that allowed set aside land to be used for non-food crop production, resulting in increased planting of rapeseed. At the same time, biodiesel has not been subject to the level of trade protection facing ethanol and, thus, would be unlikely to be as heavily affected by trade liberalization.

4.20 There are technical barriers to trade. Some may be legitimate and even welfare-enhancing, but they impede trade. The topic receiving the greatest attention at the moment is ensuring environmental sustainability of biofuel production, as witnessed by a call for an EU-wide ban on palm oil from Southeast Asia. Work is underway in the European Union as well as by associations such as RSPO to draft sustainability criteria and certification procedures. From the point of view of global environmental sustainability, however, only worldwide certification of most biofuels that is effectively enforced may have a reasonable chance of making a difference. Selective certification that leaves some biofuels uncertified could give the appearance of sustainable production to some while allowing the practice of unsustainable production for other consumers. In the extreme, depending on the manner in which uncertified biofuels are produced, considerable environmental damage may still be incurred even if a majority of biofuels is certified. This would argue for rapidly building a consensus on what would be a realistic way forward to ensure global environmental sustainability.

4.21 In addition, unlike ethanol, biodiesel properties and performance vary depending on the feedstock, and some feedstocks (such as rapeseed) make biodiesel that is inherently more suitable for cold-climate applications than others (such as palm). The United States and the European Union have issued biodiesel specifications and associated test methods, but more work is needed. The existing specifications and test methods are inadequate even for biodiesel fuels made from domestic feedstocks (for which these specifications are intended). As paragraph 3.81 suggests, some test methods cannot be used for biodiesel fuels made from certain feedstocks.

4.22 Preceding chapters suggest that, for both ethanol and biodiesel, the core policy issues affecting the potential for beneficial trade are

(1) Import barriers

(2) The agricultural policy regimes (including domestic support and market access) affecting feedstocks

(3) Tax reduction and production subsidies affecting biofuels themselves.

4.23 If biofuels are economic, nearly all countries would presumably consume biofuels on the domestic market first—at least to the point that can be fully utilized by the existing vehicle fleet—before exporting, since selling into the domestic market is nearly universally more profitable than exporting. An exception would be countries with surplus supply. Brazil is one clear example of a surplus-ethanol country, and hence would benefit from trade liberalization, as one study on the U.S.-Brazil ethanol trade described in chapter 3 showed. Worldwide, total cropland has been relatively stable. Some parts of Latin America—notably Brazil, and to a lesser extent Argentina—and sub-Saharan Africa have surplus land that has not been brought into production. Vast rainforests in Indonesia are also suitable for palm cultivation but environmental concerns would need to be addressed for massive expansion in biofuel production to be sustainable. Most developing countries are densely populated and do not have large tracts of underutilized lands that could be used for crops or biofuels. Unutilized land in sub-Saharan Africa faces a number of obstacles before it can be profitably brought into production. These obstacles include poor infrastructure, underdeveloped financial markets, and a hostile investment climate on account of (often inappropriate) government policies and poor governance.

4.24 If biofuels are not economic but some governments are prepared to offer considerable price subsidies, trade opportunities might arise for countries with duty-free access. Indeed, some countries in Eastern Europe and former Soviet Union Republics are launching or planning to start biodiesel production with a view to exporting to the European Union. The financial viability of such trade, however, obviously depends critically on the political decisions in the countries providing large subsidies. The sustainability of such trade is uncertain.

4.25 In general, lowering trade barriers increases global welfare in the long run, and biofuel trade is no exception. Bringing down border barriers to biofuel trade would increase competition, which should in turn help improve efficiency, bring down costs, and enable the world's most efficient producers to expand their market share. As the study on U.S.-Brazil ethanol trade cited in chapter 3 shows, removal of high tariffs would bring down prices in highly protected markets and increase consumption.

4.26 There is an important difference between ethanol and biodiesel trade. Quality and quality consistency are far more likely to be an issue with biodiesel than with ethanol, as explained in chapter 1. As discussed in 2.46, it may make more sense for Europe, for example, to import biodiesel feedstocks than biodiesel. Removal by major oilseed producers of differentiated export taxes that are currently in favor of biodiesel may increase feedstock trade, provided that there are no barriers in importing countries. Ethanol does not have quality consistency problems nearly to the same extent as biodiesel and is more likely to be exported as a finished product, but it encounters high border tariffs in major potential importers today. Sugar cane degrades rapidly and is clearly unsuited for export. In some circumstances, it might make more economic sense to import grains and process them into ethanol near consumption centers.

4.27 There is one caveat concerning the benefits of reducing and eventually eliminating border barriers. If biofuels continue to require very large subsidies, simply lowering import tariffs on biofuels may merely serve to enlarge an industry that cannot stand on its own, and make future adjustments even more painful should subsidies be substantially curtailed or withdrawn one day. Biofuel trade liberalization coupled with continued agricultural and biofuel policies that distort markets for biofuels could prolong and even worsen those distortions, as additional markets for subsidized agricultural outputs and biofuels would be created. The three sets of policies mentioned in paragraph 4.22 are closely interwoven, and the theory of second best (Lipsey and Lancaster 1956–57) suggests that it would not necessarily improve overall welfare to address biofuel trade separately from other distortions affecting biofuels and biofuel feedstocks.

4.28 The general conclusion that emerges from the body of literature currently in existence on agricultural and biofuels policies is that trade liberalization for biofuels should ideally be considered part of the broader set of issues in the Doha Round of trade negotiations. To do otherwise would benefit consumers in highly protected countries and some interests (for example, ethanol and feedstock producers in Brazil and Pakistan, and those countries where certain commodity prices switch from being export-parity to import-parity as a result), but it would not necessarily move the world closer to resolution of broader issues affecting the biofuel market. On the other hand, reform must start somewhere—even if in piecemeal fashion—if a program of reform is to be eventually achieved. Beginning the overall trade liberalization process with ethanol and biodiesel presents the advantage of forcing governments to openly address the question (and the costs) of what objectives their biofuel support policies are actually pursuing.

Annex 1

Issues in Agriculture and Environment under WTO

A1.1 The Agreement on Agriculture was negotiated during the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) and entered into force with the establishment of the WTO on January 1, 1995. Its implementation period was six years for developed countries.[18] Developing countries were given the flexibility to implement their reductions in trade restrictions and other specific commitments over a period of up to 10 years. The least developed countries were effectively exempted from subsidy and tariff reductions. The Agreement did not achieve the reforms hoped for, and the launch of the Doha Round in November 2001 was seen as an opportunity to strengthen the disciplines of the Agreement on Agriculture and focus on issues of importance to developing countries under the Doha Development Agenda. Unfortunately, the Doha Round has encountered the same opposition to reforms in agriculture as the Uruguay Round. Pascal Lamy, WTO Director General, suspended the Doha WTO negotiations in July 2006 after failure to reach agreement on the issues of domestic support and market access for agriculture.

A1.2 The long-term objective of the Agreement is "to establish a fair and market-oriented agricultural trading system." It recognizes that reform agreements must look beyond import access restrictions and touch upon all measures affecting trade in agriculture, including domestic agricultural policies and the subsidization of agricultural exports. The Agreement on Agriculture is especially relevant for ethanol, which is currently classified as an agricultural good under the WCO's Harmonized Commodity Description and Coding System (or HS for short).

Three Pillars in the Agreement on Agriculture

A1.3 The Agreement on Agriculture has three main areas for negotiation: reducing domestic support, increasing market access, and reducing export subsidies.

Domestic support

A1.4 The first pillar of the Agreement on Agriculture aims to reduce domestic subsidies. The subsidies are divided into three categories or "boxes." As discussed in chapter 3, a question being posed is whether subsidies for biofuel feedstock production

[18] For the use of "developed," "developing," and "least developed" countries in this report, see footnote 11 in chapter 1.

(or biofuel production itself if farmers can be shown to benefit directly from the subsidies, and for ethanol if WTO members notify subsidies for ethanol as agricultural subsidies) can be classified as green box policies in the following classification system.

- The amber box contains domestic subsidies that are deemed to distort trade and that governments have agreed to reduce but not eliminate. The reductions are based on a formula called the Aggregate Measure of Support (AMS), accompanied by de minimis, a minimum threshold below which spending on domestic subsidies does not need to be included in the AMS calculations. The European Union provides the largest amount of amber-box support as measured by dollar value—more than half of the world's total—with the United States a distant second and Japan a distant third (CBO 2005).
- The blue box contains subsidies that can be increased without limit, provided payments are linked to production-limiting programs. The level of payment is based on fixed areas and yields, or per head of livestock. Very few developing countries have programs that can be classified under the blue box category.
- The green box policies are those that are expected to have a minimal or no impact on trade and are not subject to annual limits. The green box payments include those for environmental programs, pest and disease control, infrastructure development, domestic food aid (purchased at market prices), and income insurance and emergency programs, and direct payments to producers provided they are decoupled from current production levels. The bulk of domestic support provided by the United States and Japan falls into the green box (CBO 2005).

Market access

A1.5 Market access refers to the reduction of tariff and non-tariff barriers to trade. Least developed countries were exempted from tariff reductions, but either had to convert non-tariff barriers to tariffs in a process called tarification, or create a ceiling for their tariffs that could not be increased. Ethanol tends to encounter much greater tariff barriers than biodiesel.

Export subsidies

A1.6 The Agreement on Agriculture required developed countries to reduce export subsidies by at least 35 percent by value or 21 percent by volume over five years to 2000. The European Union is by far the dominant provider of export subsidies, providing 85 percent to 90 percent of the world's total (CBO 2005).

Other provisions

A1.7 Several provisions permit greater protection of certain commodities or by certain countries under the Agreement. They include special and differential treatment, special products, and sensitive products. No products have been explicitly classified as sensitive or special products to date. These classifications are due to be made once decisions on modalities are finalized. Negotiations have included how many tariff lines developed countries will be allowed to categorize as sensitive and their treatment, including tariff reductions and tariff quota expansions.

A1.8 *Special and differential treatment* allows exports from developing countries to receive preferential access to developed markets without having to accord the same treatment in their domestic markets. It recognizes that developing countries face greater difficulties in world trade, and hence should be granted greater flexibility in moving toward a market-based system. Numerous developing countries enjoy preferential access to the European Union for ethanol and sugar.

A1.9 *Special products* can be claimed by developing countries only. This mechanism was created to protect and promote food production, livelihood security, and rural development. Developing countries can designate a certain number of products that would be exempt from tariff reduction requirements and other disciplines.

A1.10 *Sensitive products* can be claimed by developed countries to continue protection of particular agricultural products for political, social, or cultural reasons. Sensitive products receive less rigorous disciplines in relation to tariff and domestic support reductions. In exchange, tariff rate quotas on the products are expanded. The European Union is currently asking for 8 percent of product lines to be deemed sensitive and given special levels of protection, against 1 percent proposed by the United States. Declaring ethanol a sensitive product would enable a country to protect its domestic ethanol industry longer.

Environmental Goods and Services

A1.11 The Doha Ministerial Declaration of 2001 specifically referred to environmental goods and services as an area that could be targeted for faster liberalization. Under paragraph 31 (iii), WTO members agreed to negotiate "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services [with a view to enhancing the mutual supportiveness of trade and environment]" (WTO 2006). The declaration did not attempt to define, and there is, as yet, no agreement on, what constitutes environmental goods and services, nor are there agreed criteria for their classification. Negotiations on environmental goods have been assigned to the Non-Agricultural Market Access Negotiating Group—which could be interpreted to mean that environmental goods are non-agricultural products; negotiations on environmental services have been assigned to the meetings of the Committee on Trade and Environment meeting in Special Sessions. The Committee on Trade and Environment has remained the main body where the debate on the scope of this paragraph occurs.

A1.12 One question is whether agricultural goods could qualify as environmental goods, or whether only industrial goods (such as pollution reduction equipment) could. Those wishing to protect domestic ethanol producers against cheaper imports would argue against classifying ethanol as an environmental good, while those who stand to benefit from liberalized trade would argue the reverse.

A1.13 Although the WTO has not formulated a definition, definitions for the environmental industry have been proposed by other international organizations. The

United Nations Conference on Trade and Development (UNCTAD) defined environmentally preferable products as “products which cause significantly less environmental harm at some stage of their life cycle (production/processing, consumption, waste disposal) than alternative products that serve the same purposes, or products the production and sale of which contribute significantly to the preservation of the environment” (UNCTAD 1995). An informal working group meeting under the auspices of the OECD and the Statistical Office of the European Communities defined the environmental goods and services industry to consist of activities “which include those that measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems” (OECD/Eurostat 1999). These definitions have been referred to in the WTO negotiations.

A1.14 There is less common understanding of environmental goods than environmental services. OECD and the Asia-Pacific Economic Cooperation (APEC)—which includes as its members Australia, Canada, Chile, China, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Peru, Philippines, Russia, Thailand, United States, and Vietnam—independently developed lists of environmental goods. Their objectives and procedures for generating the lists were different. OECD’s list was intended to be illustrative; APEC’s aim was to obtain more favorable tariff treatment for environmental goods and, as a result, their list was confined primarily to goods that could be readily distinguished by customs agents and treated differently for tariff purposes. APEC’s list focuses more on end-of-pipe pollution control and monitoring equipment. These differences notwithstanding, the two lists have helped frame WTO negotiations. On the basis of three broad categories used by OECD for its list—pollution management, resources management, and cleaner technologies and products—the lists contain a large number of goods under pollution management, and some under resources management including renewable energy. The items on OECD’s list under cleaner technologies and products do not appear on APEC’s list. Under renewable energy, OECD’s list, but not APEC’s, includes ethanol. Neither contains biodiesel (Steenblick 2005a).

A1.15 Discussions on definition and classification of environmental goods stalled long before the suspension of WTO negotiations in July 2006. Developing countries are concerned that negotiations have focused on high-technology products of little export interest to them. At a meeting of the WTO Committee on Trade and Environment Special (negotiating) Session in July 2005, Brazil proposed classifying ethanol and biodiesel—as well as flex-fuel engines and vehicles—as environmental goods. Prior to this session, both Canada and New Zealand had submitted lists of proposed environmental goods that included biodiesel.

A1.16 Another issue is whether distinctions should be made on the basis of process and production methods. Requiring that a good be produced in an environmentally sustainable manner seems consistent with the spirit of paragraph 31 in the Doha Ministerial Declaration, whereby increased trade resulting from liberalization is expected to promote both environmental protection and economic development. It is also consistent with the definition of environmentally preferable products. However, such distinction would make administration more complex.

A1.17 A related question is whether ethanol for fuel use should be classified as a non-agricultural product. The Doha Ministerial Declaration also had a paragraph on market access for non-agricultural products. In paragraph 16, WTO members agreed to "negotiations which shall aim, by modalities to be agreed, to reduce or as appropriate eliminate tariffs, including the reduction or elimination of tariff peaks, high tariffs, and tariff escalation, as well as non-tariff barriers, in particular on products of export interest to developing countries. Product coverage shall be comprehensive and without a priori exclusions. The negotiations shall take fully into account the special needs and interests of developing and least-developed country participants, including through less than full reciprocity in reduction commitments" (WTO 2006). Biofuels are likely to be products of export interest to developing countries.

A1.18 There are no large tariff barriers in major current and future biodiesel consumers and potential importers. As an industrial good, the tariffs that do apply to biodiesel may be tackled under paragraph 16 of the Doha Ministerial Declaration. Some countries are also proposing to classify biodiesel as an environmental good with a (long-term) objective of accelerating tariff reduction and elimination further.

Annex 2

EU and U.S. Agricultural Policies

A2.1 Many agricultural policies date back more than a century and some of the first policies to protect agricultural producers were in Europe in the 1800s, when for example, sugar beet producers in Europe could not compete with lower-cost sugar produced from cane outside of Europe. This led to high import duties on cane sugar from the Caribbean. Opposition to high protection also dates back several centuries and the English economist David Ricardo was one of the first to argue against Britain's early-nineteenth-century agricultural protection, the so-called Corn Laws, which imposed high duties on wheat imports (Ricardo 1817). Since then, many countries have bowed to political pressure from farm groups or concerns over food security and provided direct or indirect support to domestic producers and protection from lower-cost foreign producers. Often this support was intended as a temporary measure to protect producers from low prices, but became permanent when prices remained low for a sustained period of time. There are many different ways policies can be used to protect agricultural producers, as evident from the policies overviewed in this section.

A2.2 OECD countries provide significant protection to domestic farmers in the form of high import tariffs and subsidies. The most recent figures from the OECD show that the amount its thirty members spent on domestic agriculture in 2005 was essentially unchanged from 2004 at US$280 billion. Subsidies accounted for close to one-third of farm incomes. EU aid to its farmers fell marginally from US$136 billion to US$134 billion while Japanese farmers remained among the most protected. The producer support estimate—which measures the cost to taxpayers of subsidies and consumers of tariff barriers—was 32 per cent in the European Union and 56 per cent in Japan. The $43 billion support given by the U.S. government represented 16 percent of receipts.

A2.3 The two most important economies that have historically restricted biofuel trade to protect domestic farmers are the European Union and the United States. Their agricultural policies are described in this annex.

European Union

A2.4 The European Union's Common Agricultural Policy (CAP) dates to 1958.[19] The stated objectives of the CAP are to increase agricultural productivity; ensure a fair standard of living for farmers; stabilize markets; guarantee regular food supplies; and ensure reasonable prices to consumers. Domestic price supports are the historical backbone of CAP farm support, although price support has become less important for maintaining grain and beef farmers' incomes under the CAP reforms. High domestic prices were maintained by price intervention and high external tariffs, whereby authorities buy surplus supplies of products when market prices threaten to fall below agreed intervention (minimum) prices. High tariffs limit imports of most price-supported commodities and allow the high internal market price set by EU authorities to be maintained. Farmers are guaranteed intervention prices for eligible agricultural products. This means that EU authorities will purchase, at the intervention price, unlimited excess products that meet minimum quality requirements and that cannot be sold on the market. The surplus commodities are then put into EU storage facilities or exported with subsidy. While less important from a budget perspective, exports of processed products that contain a portion of a CAP-supported commodity also receive an export subsidy, based on the proportion of the commodity in the product and the difference between the intervention price and the world price. Other mechanisms, such as consumer subsidies paid to encourage domestic consumption of products like butter and skimmed milk powder, also support domestic prices.

A2.5 Reforms of the CAP began in 1992, when supply controls through a mandatory, paid, set-aside program to limit production were instituted. These supply controls have been maintained through subsequent reforms. To be eligible for direct payments, producers of grains, oilseeds, or protein crops must remove a specified percentage of their area from production.

A2.6 The second reform, Agenda 2000, began preparation for EU enlargement, and, like the first CAP reform, used direct payments to compensate farmers for half of the loss from new support price cuts. Agenda 2000 set the base rate for the required set-aside for arable crops at 10 percent. Producers with an area planted with these crops sufficient to produce no more than 92 metric tonnes of grain are classified as small producers and are exempt from the set-aside requirement. Supply-control quotas have been in effect for the dairy and sugar sectors for nearly two decades.

A2.7 The most recent reforms began as a mid-term review of Agenda 2000 and resulted in a third major set of reforms in June 2003 and April 2004. These latest reforms represent a degree of re-nationalization of farm policy, as each member state will have

---

[19] The CAP was agreed to at the Stresa conference in July 1958 for the then-six members of the European Economic Community. The CAP established a common pricing system for all farmers in the European Economic Community, and it fixed agricultural prices above world market levels to protect farmers in member countries who generally had higher production costs than other world market producers. Commodities covered by the CAP included cereals, beef, butter and skimmed milk powder, fruits and vegetables, and olive oil. Sugar was included in 1968 and EU sugar policy remained largely unchanged until major reforms were agreed in November 2005.

discretion over the timing and method of implementation. The 2003 reforms allow for decoupled payments—payments that do not affect production decisions—that vary by commodity. Called single farm payments, these decoupled payments are based on 2000–02 historical payments and replace the compensation payments begun by the 1992 reform. When member states implement the reforms, compliance with EU regulations regarding environment, animal welfare, and food quality and safety will be required to receive single farm payments. Moreover, land not farmed must be maintained in good agricultural condition. Coupled payments, which can differ by commodity and require planting a crop, are allowed to continue to reinforce environmental and economic goals in marginal areas. The CAP budget ceiling has been fixed from 2006 to 2013, and—if market support and direct payments combine to come within €300 million of the budget ceiling—single farm payments will be reduced to stay within budget limits.

A2.8 The 2003 reforms cut storage subsidies by 50 percent. Reforms have lowered the cost of the CAP to consumers as intervention prices have been reduced. However, taxpayers now bear a larger share of the cost because more support is provided through direct payments.

A2.9 Direct payments are made to producers to provide substantial income support, but price supports remain a principal means of maintaining farm income. Compensation payments for price cuts generated by the 1992 reform began in 1994 and were increased for the price cuts of the Agenda 2000 reform. These compensation payments were established on a historical-yield basis for arable crops by farm, and farmers had to plant to receive the payment. In contrast, the payments specified in the 2003 reform will be made to farmers based on the average level of payments made during 2000–02 and no production is required. Direct payments currently account for about 35 percent of EU producer receipts and for an even higher percent of net farmer income once input costs are subtracted from receipts.

A2.10 In preferential trade agreements, such as those with former colonies and neighboring countries, the European Union satisfies consumer demand while protecting high domestic prices through import quotas and minimum import price requirements. The CAP also applies tariffs at EU borders so that imports cannot be sold domestically below the internal market prices set by the CAP. Although the Uruguay Round Agreement on Agriculture called for more access to the EU market, market access to the European Union's agricultural sector remains highly restricted in practice. In addition, the European Union subsidizes agricultural exports to make domestic agricultural products competitive in world markets.

A2.11 The CAP regime covers most grain produced by and imported into EU countries (bread wheat, barley, and maize). However, high prices for some grains indirectly raise the prices of unsupported grains, principally feed wheat. As with other commodities, grain support mechanisms include a mixture of price supports and supply controls, as described above. CAP reforms have affected the grain regime mainly by requiring grain farmers to remove a percentage of their arable cropland from production in order to receive direct (coupled) payments in compensation for reduced price supports. The 2003 reforms required a decoupled payment of at least 75 percent for arable crops.

Since a decoupled payment does not require a crop to be planted or produced to receive payment, farmers are free to plant whatever crop they want or to not plant at all. Durum wheat was allowed a 40-percent coupled payment in traditional areas, while support for durum in nontraditional areas was abolished. In addition, storage payments for grains were cut by 50 percent. Nevertheless, most EU grain prices will likely remain above world prices most of the time, requiring export subsidies to remain competitive on the world market (USDA 2006c).

United States

A2.12 U.S. government support to commodity producers is provided under farm legislation, which typically extends for five years. The most recent of these "Farm Bills" was *The Farm Security and Rural Investment Act of 2002*, and it is scheduled to expire in 2007. It provides direct government income support to eligible commodity producers, mainly through three programs: direct payments, counter-cyclical payments, and the marketing loan program. In addition, subsidized crop and revenue insurance is provided to assist farmers with risk management. Commodity producers also receive benefits from government programs promoting trade liberalization and food aid. Specific programs apply to individual crops.

A2.13 *Direct payments* are fixed payments made annually to farmers who participate in the program. They are decoupled from production: they are made regardless of the level of production or which of the eligible crops are grown. Eligible crops include maize, sorghum, barley, oats, wheat, upland cotton, rice, soybeans, other oilseeds, and peanuts. The direct payment is calculated by multiplying the commodity payment rate by the farm's payment yield and 85 percent of the farm's base acres. The maize payment rate is US$0.28 per bushel (US$11 per metric tonne). Payment yields are based on historical farm maize yields, and base acres depend on historical farm plantings.

A2.14 The *marketing assistance loan program* provides non-recourse loans[20] to eligible producers, with the farm's program crop used as collateral. The marketing loan for maize is US$1.98 per bushel (US$77 per metric tonne), and producers may settle the loan either by forfeiting the collateral to the Commodity Credit Corporation (CCC) at maturity with no penalty or by repaying the loan. Producers may forgo taking out a loan and instead receive a loan deficiency payment equal to the difference between the posted county price and local loan rate on the quantity eligible for loan.

A2.15 *Counter-cyclical payments* (CCPs) are available to farmers whenever the effective price of maize is lower than the target price of US$2.60 per bushel (US$102 per metric tonne). The effective price is the sum of the direct payment rate and the larger of the national average farm price or the national average loan rate. The difference between the effective and target price is the counter-cyclical payment rate paid on a farm's base acres and payment yields. CCPs are made to eligible farmers regardless of the level of production or which crops are grown on the farm. A farm's CCPs are equal to the product of the counter-cyclical payment rate, the payment yield, and 85 percent of the farmer's base acres.

[20] A non-recourse loan limits the lender's rights to the particular asset being financed, crops in this case.

A2.16 Commodity producers can also purchase subsidized crop or revenue insurance to manage these risks, and U.S. Department of Agriculture's (USDA) Risk Management Agency pays a portion of contract premiums for producers' insurance policies and some of the delivery and administrative costs of private insurance companies that sell these policies. In 2001, 74 percent of maize planted areas were covered by crop or revenue insurance. The USDA's Foreign Agricultural Service also promotes exports of U.S. feed grains under the Export Credit Guarantee Program (GSM-102) and the Intermediate Export Credit Guarantee Program (GSM-103). These credit programs are used to underwrite credit extended by U.S. banks to approved foreign banks to pay for food and agricultural products sold to foreign buyers. The credit programs provide assurance to U.S. exporters that they will be paid. In addition, as part of U.S. food-aid programs, USDA provides low-interest loans to qualified developing countries purchasing U.S. commodities. Finally, under the 2002 Farm Act, producers can choose from a wide range of voluntary conservation and environmental programs designed to protect multiple resources. Land retirement programs—including the Conservation Reserve Program, Conservation Reserve Enhancement Program, Wetland Pilot Program, and Wetlands Reserve Program—remove land from production. Working lands programs, such as the Environmental Quality Incentives Program and the new Conservation Security Program, provide assistance on lands in production (USDA 2002).

Annex 3

Biofuel Policies in Different Countries

A3.1 Biofuels are protected by a complex web of subsidies in North America and the United States. This annex gives more details on biofuel policies in the European Union and the United States. A significant portion of the materials on the European Union iw drawn from Kutas and Lindberg (forthcoming). The annex also provides information on biofuel policies in Argentina, Australia Canada, China, Colombia, Indonesia, and Japan.

European Union

A3.2 The European Union produced 3.2 million tonnes of biodiesel in 2005 (EBB 2007a), mostly from rapeseed oil. The European Union produced approximately 1.6 billion liters of bioethanol in 2006, representing an increase of 71 percent from the previous year (Ebio 2007). Countries producing 500,000 tonnes or more of biodiesel in 2006 are Germany, France, and Italy;[21] those producing 200 million liters or more of bioethanol in 2006 are Germany, Spain, and France.

A3.3 As described in chapter 3, Article 16 of the Energy Tax Directive permits member states to exempt or reduce excise taxes on biofuels. Austria, Belgium, Denmark, Estonia, Germany, Italy, Ireland, Lithuania, and the United Kingdom have notified the European Commission and received state aide approval for ethanol; France and Hungary have received state aid approval for ethyl tertiary-butyl ether (ETBE); Austria, Belgium, the Czech Republic, Denmark, Estonia, Germany, Hungary, Italy, Ireland, Lithuania, and the United Kingdom have received state aid approval for biodiesel; and Austria, Belgium, Estonia, Germany, Ireland, Lithuania have received state aid approval for vegetable oils; and Sweden has received state aid approval for all so-called carbon-dioxide (CO_2)-neutral fuels.

A3.4 Set-aside land accounts for about 10 percent of total EU farmland. In 2005, of the 7.0 million hectares of set-aside land, 836,000 hectares were planted with feedstocks for biofuels. Farmers are compensated for setting aside land. Set-aside land planted with energy crops is not eligible for the €45-per-hectare payment under the

[21] Aggregate EU biodiesel production in 2006 is not stated in the report because different sources give different estimates, and the production figures from the European Biodiesel Board, which is the primary source of EU data for this report, were not available at the time of publication.

Energy Crop Scheme introduced in 2003. However, sugar beets grown as a non-food crop will qualify for set-aside payments *and* energy crop aid, and will also be exempted from production quotas.

A3.5 Several countries have mandatory blending requirements. In Austria, beginning in October 2005, those who enter the gasoline and diesel fuel market for the first time must have 2.5 percent biofuel, calculated on the basis of energy content. This percentage will rise to 4.3 percent in October 2007 and 5.75 percent in October 2008. A description of biofuel policies in the top three biodiesel and bioethanol producers (Germany, France, Spain, and Italy) as well as Sweden—which in 2004 exceeded the biofuel consumption target set by the EU Biofuels Directive for 2005—is given next.

A3.6 Germany has historically provided generous fuel-excise-tax concessions with no quantitative restrictions. Full excise tax exemption has been granted to biofuels and heating oils produced from biomass, whether sold pure or blended. Historical tax exemptions have amounted to €0.4704 (US$0.64) per liter of biodiesel and vegetable oil, and €0.6545 (US$0.88) per liter of ethanol and ETBE. The exemption must be adjusted if over-compensation is established. In August 2006, in the light of falling world crude oil prices, the government introduced a fuel excise tax of €0.09 per liter of biodiesel and straight vegetable oil for automotive use. Capital grants are also given for bioenergy. The government also funds R&D projects. Germany has maintained an end-user price advantage for biodiesel over petroleum diesel through combined exemption of fuel excise tax and ecological tax which is €0.10 per liter.

A3.7 In October 2006, Germany issued new legislation requiring mandatory blending of biodiesel and bioethanol and gradually phasing out fuel tax reductions beginning in 2007. There are penalties for failing to meet the blending targets, which are set at 4.4 percent for biodiesel and 1.2 percent for ethanol in 2007 and rise over the coming years. By 2011 both biodiesel and straight vegetable oil will be taxed at €0.323 (US$0.44) per liter, and in 2012 the tax rate will rise to €0.449 (US$0.61). Biogas and liquid biofuels produced using biomass-to-liquid technologies will continue to enjoy 100 percent tax exemption until 2015.

A3.8 France is a major producer, within the European Union, of both biodiesel and ethanol. Ethanol, made from wheat and sugar beets, has historically been converted to ETBE before being blended into gasoline. The country's biofuel industry was aided by the Biofuel Production Program, which has in the past provided capital grants. Fuel excise taxes are reduced by €0.33 (US$0.45) per liter for ethanol in ETBE or blended into gasoline and €0.25 (US$0.34) per liter for biodiesel (USDA 2006j). These tax reductions are not automatically granted. Each year, the government establishes a quota for the maximum volume of biofuels that are given the tax relief. This annual adjustment is intended to take into account varying production costs and petroleum fuel prices, and to avoid possible over-compensation. A public tender system is used to allocate eligible biofuel production quantities to production units approved by the government. Production quotas are being raised sharply in the coming years: doubling for biodiesel between 2006 and 2007 and doubling again between 2007 and 2009; tripling for ethanol between 2006 and 2008. The government also imposes a tax on fuel distributors failing to meet a biofuel blending rate, set at 1.75 percent in 2006, 3.5 percent in 2007, 3.5 percent in 2008, 6.25 percent in 2009 and 7 percent in 2010 (USDA 2007n). No capital grant programs appear to be in place at present. The government funds R&D for biofuels. France has just set a target of 15 percent for the percentage of state-purchased vehicles that are flex-fuel in 2007, doubling to 30 percent in 2008. The country also plans to install 500 E85 pumps by September (*Dow Jones International News* 2007b).

A3.9 Italy was the third largest biodiesel producer in the European Union in 2006, but it manufactures biodiesel mainly from imported vegetable oils. Italy grants tax exemption to biodiesel but limits the quantity of biodiesel that enjoys the exemption. The annual quota was increased from 125,000 tonnes to 300,000 tonnes in 2002, but reduced to 200,000 tonnes in 2005. The exemption amounts to €0.413 (US$0.56) per liter, subject to adjustment for over-compensation. Italy was also the fifth largest producer of ethanol in the European Union in 2006. According to the government, the reduction in the quota of biodiesel eligible for fuel tax exemption was to permit tax relief for ethanol which, unlike biodiesel, might use domestic feedstocks. In 2005, ethanol and ETBE were given a fuel-excise-tax reduction of €0.26 (US$0.35) and €0.25427 (US$0.34) per liter, respectively.

A3.10 Spain was the European Union's second largest producer of ethanol in 2006, made from wheat and barley. As in France, most of its ethanol is converted to ETBE. Full excise tax exemption is granted for biofuels until the end of 2012, amounting to €0.42 (US$0.57) per liter for ethanol and €0.29 (US$0.39) per liter for biodiesel. The government has provided other forms of assistance, although apparently in limited amounts: capital grants, a reduction of 0.5 percent in the interest rate for eligible projects, and a tax deduction for investments in tangible fixed assets that would use renewable sources.

A3.11 Sweden is a large importer of ethanol in addition to being the fourth largest EU ethanol producer in 2006. It has limited biodiesel production. In 2004, biofuel use averaged 2.3 percent of all transportation fuel consumption, thus exceeding the 2 percent target set in the Biofuels Directive for end-2005. In 2005, Sweden was the only country in which direct gasoline-ethanol blends were produced and where ethanol consumption exceeded domestic ethanol production. Ethanol imported from Brazil comprised 70 percent of total consumption in 2005, imported blended with 20 percent gasoline under an "other chemicals" tariff line and subject to a markedly lower tariff rate. Ethanol imported under the "other chemicals" tariff code could also benefit from Swedish tax relief for biofuels, described in the next paragraph. In January 2006, the tax relief was made available only for ethanol imported under the higher EU duty of €0.192 a liter (USDA 2006g). This policy change was largely responsible for Brazilian ethanol imports into the European Union falling from about 300 million liters in 2005 to 233 million liters in 2006 (*Dow Jones International News* 2007b)

A3.12 Swedish excise duties consist of an energy tax and a CO_2 tax. Once a fuel is deemed by the authorities to be CO_2-neutral, the CO_2 tax is waived. Biofuels have been classified as being CO_2-neutral, and all biofuels, domestic and imported, are eligible for exemption from the CO_2 tax. The exemption applies until the end of 2007, subject to adjustment if over-compensation is established. The CO_2 tax is set at SKr1.46 (US$0.21) per liter for gasoline and SKr1.80 (US$0.26) per liter for diesel. In 2004, the government introduced a five-year program whereby CO_2-neutral fuels are exempt from both CO_2 and energy taxes. This tax measure was approved by the European Commission in March 2006. This would increase the tax exemption to SKr4.62 (US$0.68) per liter of ethanol and SKr3.12 (US$0.46) per liter of biodiesel. Full tax exemption has historically been given to biofuels produced in pilot plants. Because the European Commission considers ethanol technologies sufficiently commercially proven, ethanol pilot projects must first obtain approval of the European Commission to be eligible for the tax exemption. There appear to be no capital grants provided for biofuel manufacturing plants. Some funding has been provided for R&D.

The EU Strategy for Biofuels

A3.13 "An EU Strategy for Biofuels" issued in February 2006 sets out a strategic approach to support market growth of both first-generation biofuels and second-generation biofuels. The latter include lingo-cellulosic processing and conversion of biomass to liquid dimethyl ether and Fischer-Tropsch biodiesel. The strategy acknowledges both the comparative advantage of developing countries in the production of biofuels and environmental and social concerns in the event of large-scale expansion of feedstock production. The latter includes pressures on eco-sensitive areas such as rainforests (for palm plantation, for example); effects on soil fertility, water availability and quality, and pesticide use; potential dislocation of communities; and competition between biofuel and food production. The strategy presents seven policy axes, as follows:

- Stimulating demand for biofuels through national targets, favorable treatment to second-generation biofuels, and promotion of public procurement of vehicles using high blends of biofuels
- Capturing environmental benefits including GHG emission reduction and ensuring sustainable cultivation of biofuel feedstocks
- Developing the production and distribution of biofuels by considering biofuels in national plans for rural development and ensuring no discrimination against biofuels
- Expanding feedstock supplies through incentive schemes, information campaigns for farmers and forest holders, studying legislation revision to facilitate authorization and approval processes for biofuel production, and monitoring the impact of biofuel demand on commodity and byproduct prices
- Enhancing trade opportunities through assessing advantages, disadvantages, and legal implications of proposing separate nomenclature codes for biofuels; not worsening market access conditions for imported bioethanol; and pursuing a balanced approach
- Supporting developing countries by ensuring that support for the countries affected by the EU sugar reform can help develop bioethanol production; developing a coherent biofuels assistance package; and examining how best to assist in the development of biofuel programs that are environmentally and economically sustainable

- Supporting R&D.

Biofuel import tariffs

A3.14 Biodiesel imports into the European Union are subject to an ad valorem duty of 6.5 percent. An import duty of €0.192 per liter is levied on undenatured ethanol, and €0.102 per liter on denatured ethanol. Between 2002 and 2004, 93 percent of ethanol imported into the European Union was undenatured. In 2004, 55 percent of ethanol imported was free of import duties. Until recently, Pakistan was the largest duty-free exporter. Pakistan lost its duty-free status in 2005, and is now subject to full import duties. Brazil exported even greater amounts to the European Union as a most-favored-nation (MFN) exporter with no duty exemptions or reductions. Three categories of countries and Egypt and Norway enjoy an unlimited duty-free status in respect of ethanol.

- The Generalized System of Preferences Plus (GSP+) incentive scheme covers Bolivia, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Panama, Peru, El Salvador, Venezuela, Georgia, Sri Lanka, Mongolia, and Moldova, and grants them unlimited and duty-free access for denatured and undenatured ethanol. The scheme is in effect from January 1, 2006 to December 31, 2008.
- The Everything-But-Arms (EBA) initiative covers 50 developing countries and grants unlimited duty-free access to denatured and undenatured ethanol.
- Under the Cotonou Agreement, all ACP (Africa, Caribbean, and Pacific) countries, of which there are 79, quality for unlimited duty-free access for denatured and undenatured ethanol with the sole exception of South Africa. These countries include all the EBA countries in Africa, the Caribbean, and the Pacific.
- Egypt has unlimited duty-free access under the Euro-Mediterranean Agreement, and Norway has been granted duty-free access under the system of tariff rate quotas.

A3.15 In 2004, 45 percent of ethanol imported into the European Union was from GSP+ countries. Full import duties were levied on 36 percent of the total imports. Despite import duty concessions, ACP and EBA countries combined accounted for a mere 5.6 percent. If successfully completed, the on-going negotiations on a free trade agreement between the European Union and the Mercosur (Argentina, Brazil, Paraguay, and Uruguay) could have a significant impact on ethanol imports from Brazil to Europe.

United States

A3.16 Total production of fuel ethanol in the United States in 2006 was 18.4 billion liters. In the absence of mandates until recently, U.S. ethanol production has historically been responsive to feedstock prices, such as when ethanol production plummeted in mid-1996 when maize prices reached historic highs. As of May 2007, there were 118 ethanol plants in the United States, with a combined total annual capacity of 23 billion liters, up from 16.4 billion liters in January 2006. Another 24 billion liters worth of annual capacity was being added through plant construction and expansion. Of the existing plant capacity, 34 percent was farm-owned, but of the new planned capacity, only 12 percent would be farm-owned (RFA 2007). This reversion to the ownership patterns of the 1980s for processing capacity has the potential to transfer some of the benefits of biofuel promotion policies from farmers to monopsonistic industrial interests, and to add new political dimensions to biofuel policymaking in the United States. U.S. biodiesel production tripled to 284 million liters (75 million gallons) in 2005. As of January 2007, there were 105 biodiesel production plants with a combined annual capacity of 3.3 billion liters. Seventy-seven companies reported plants under construction that were scheduled to come on stream within 18 months with a combined additional annual capacity of another 6.4 billion liters (NBD 2007).

A3.17 Much of the growth in the production of ethanol from maize is thanks to government incentive programs that began with the Energy Tax Act of 1978. This act defined gasohol as a blend of gasoline with at least 10 percent alcohol by volume, excluding alcohol made from petroleum, natural gas, or coal. A federal excise tax exemption on gasohol equivalent to US$0.40 per gallon (US$0.11 per liter) of ethanol blended was granted. This reduced the cost of ethanol to about the wholesale price of gasoline. The tax exemption was a credit that fuel blenders received for using ethanol in gasoline. Federal excise-tax exemption was supplemented by state tax incentives to ethanol producers. The tax exemption rose as high as $0.60 per gallon ((US$0.159 per liter) in the Tax Reform Act of 1984 before gradually falling to $0.51 per gallon (US$0.135 per liter) by 2005.

A3.18 Beginning in January 2005, the Volumetric Ethanol Excise Tax Credit (VEETC) in the American Jobs Creation Act of 2004 has extended the ethanol tax incentive through December 31, 2010, at a rate of US$0.51 per gallon (US$0.135 per liter) of ethanol blended. VEETC changed the tax structure by allowing a tax credit amounting to this rate on all bioethanol (and biomethanol) in ETBE or any other ether, or blended with gasoline or diesel; this removed the earlier restrictions on the percentages of ethanol that could be blended into gasoline (U.S. Congress 2004). This tax incentive does not recognize point of origin. To address concerns over Highway Trust Fund revenue losses, the American Jobs Creation Act of 2004 replaced the excise tax exemption with an income tax credit.

A3.19 The American Jobs Creation Act also provided a federal excise tax credit to biodiesel blenders: US$1.00 per gallon (US$0.26 per liter) of biodiesel made from agricultural products and US$0.50 per gallon (US$0.13 per liter) of biodiesel made from other feedstocks such as recycled oils. The tax incentive would be effective between January 2005 and December 2006 (U.S. Congress 2004). This tax credit is largely responsible for the surge in the production of biodiesel and in the growth of production capacity.

A3.20 The Energy Policy Act of 2005 contained a Renewable Fuels Standard requiring that a minimum of 7.5 billion gallons (28 billion liters) of renewable fuels be used annually in gasoline by 2012. The Act created programs and incentives to encourage the production of cellulosic biofuels and to fund research on conversion technology. Toward meeting the Renewable Fuels Standard, the Act, until 2012, counts every gallon of ethanol derived from non-grain sources (such as cellulose or waste) as 2.5 gallons of grain-based ethanol. Beginning in 2013, the Act requires a minimum of 250 million gallons (about 1 billion liters) of cellulosic biofuels to be consumed, and aims to deliver the first 1 billion gallons (3.8 billion liters) in annual production of cellulosic biofuels by 2015 (U.S. Congress 2005).

A3.21 The Act also eliminated the oxygenate mandate for reformulated gasoline. The oxygenate mandate was provided in the 1990 Clean Air Act Amendments, requiring wintertime use of oxygenated fuels in 39 non-attainment areas for carbon monoxide and year-round use of oxygenates in nine severe ozone non-attainment areas in 1995.[22] These measures provided a boost to the maize-ethanol industry. The two principal oxygenated fuels used to meet the oxygenate mandate were ethanol and methyl tertiary-butyl ether (MTBE), with ethanol used primarily in the maize-growing Midwest and MTBE elsewhere. Concerns about groundwater contamination with MTBE have led a growing number of states to ban future use of MTBE. Elimination of the oxygenate mandate means that MTBE does not have to be replaced by ethanol. In the summer of 2006, most oil companies decided to phase out MTBE altogether, creating a severe shortage of ethanol, which industry analysts regard as a one-time adjustment.

A3.22 In 2000, the USDA initiated the Bioenergy Program, administered by the Commodity Credit Corporation (CCC), to address crop surpluses and stimulate biofuel production. The program paid U.S. producers of ethanol and biodiesel to increase their production from eligible feedstocks in one fiscal year compared with the same time period in the previous year. The goals of the Bioenergy Program are stated as encouraging increased purchases of eligible feedstocks for the purpose of expanding production of such bioenergy and to support new production capacity for such bioenergy. Between fiscal years 2003 and 2006, the program was funded at up to US$150 million a year. Eligible feedstocks were listed and had to be domestically produced (USDA 2004). The program was discontinued in June 2006.

A3.23 At the state level, in addition to tax incentives, several states have adopted legislation mandating biofuel use. Most of the mandates have been approved in 2006, some dependent on minimal state production of biofuels.

- Minnesota was the first state to implement an ethanol standard. Since 1997, state law has required all gasoline sold within the state to include 10 percent ethanol. Over the 17 years prior to the mandate, the state had forgone US$155 million in revenue because there was a blender's credit of US$0.40 per gallon (US$0.106 per liter) of ethanol blended. In 2005, new legislation requiring a 20 percent ethanol standard by 2013 was signed. Through fiscal year 2006, the state of Minnesota has reportedly paid US$284 million to ethanol production plants in production subsidies.

[22] The addition of oxygen to gasoline could reduce carbon monoxide and hydrocarbon emissions in old technology vehicles if the engine is tuned with a low air-to-fuel ratio. Gasoline vehicles manufactured in the United States since the early 1990s are equipped with oxygen sensors, which automatically adjust the fuel injection rate to achieve an optimal air-to-fuel ratio, and the environmental benefit of adding oxygenates to gasoline for these vehicles is very small.

Although Minnesota is not the leading ethanol-producing state, it perhaps leads the nation in subsidies to ethanol (Koplow 2006). In September 2005, Minnesota became the first state to implement a biodiesel standard, requiring all diesel sold within the state to include 2 percent biodiesel.

- In Hawaii, regulations call for at least 85 percent of gasoline sold in the state to contain 10 percent ethanol beginning in April 2006.
- Washington approved legislation in March 2006 requiring 2 percent ethanol in gasoline and 2 percent biodiesel in diesel, with graduated increases in these requirements over future years, provided that certain supply and environmental conditions are met (Washington State Legislature 2006).
- Montana in May 2006 approved a 10 percent requirement that takes effect when ethanol production in the state reaches 40 million gallons (151 million liters) (Montana State Legislature 2005).
- Iowa in May 2006 approved legislation requiring that 10 percent of the motor fuel sold in the state contain biofuel by 2009, increasing to 25 percent by 2019. Small retailers are given a longer time period, beginning at 6 percent in 2009 and reaching 25 percent by 2021 (Iowa Legislature 2006).
- Louisiana approved a bill in June 2006 that requires gasoline sold in the state to contain at least 2 percent ethanol manufactured from domestically grown feedstock or other biomass materials within six months of annualized domestic production reaching 50 million gallons (189 million liters), and similarly diesel sold in the state to contain at least 2 percent biodiesel manufactured from domestically grown feedstock within six months of annualized domestic production reaching 10 million gallons (38 million liters) (Louisiana State Legislature 2006). There are currently no ethanol or biodiesel manufacturing plants in Louisiana.
- Missouri's Renewable Fuel Standard, signed in July 2006, requires gasoline sold in the state to contain 10 percent ethanol by January 2008 (Missouri General Assembly 2006).

A3.24 Several states have also launched initiatives to increase biofuel production. Pennsylvania in May 2006 announced a new initiative to inject 900 million gallons (3.4 billion liters) of locally produced biofuel or synthetic fuels into the state's gasoline and diesel supplies over the next decade. In April 2006, Indiana passed the Biofuels Use and Production Credits Bill, extending tax credits for ethanol and biodiesel production and offering greater incentives to companies for production of renewable fuels in the state. In March 2006, Wisconsin issued an executive order under which all state agencies would have to use E10, E85, or biodiesel in their vehicle fleets as much as possible to cut down on petroleum-based gasoline by 20 percent by 2010 and by 50 percent by 2015. The order also mandates a reduction in the use of petroleum-based diesel fuel by 10 percent by 2010 and 25 percent by 2015. Earlier in October 2005, California passed a law enabling public agencies to use vehicles that run on biodiesel and biodiesel blends, and Indiana in

April 2005 approved a bill that required renewable fuels, such as gasohol and ethanol, to be used in state-owned vehicles as much as possible.

A3.25 A detailed estimate of aggregate subsidies for biofuels can be found in Koplow (2006). Estimates are given for 2006 and as an annualized value for 2006–2012. Support for feedstock producers was pro-rated based on the share of crops used in the biofuels industry. Low and high estimates are computed, where the main difference is primarily the result of the incremental outlay equivalent value of a number of important tax breaks. The findings, given in Table A3.1, show that, in outlay equivalent, aggregate subsidies are the same order of magnitude as net-of-tax market prices of gasoline and diesel. Expressed in terms of tonne of CO_2 equivalent saved, the high 2006 estimate for ethanol gave US$520, one to two orders of magnitude higher than market carbon prices.

Table A3.1 Total Annual U.S. Support to Ethanol and Biodiesel

Year	*Unit*	*Ethanol*		*Biodiesel*	
		Low	*High*	*Low*	*High*
2006	Per liter	0.28	0.36	0.41	0.52
2006–2012	Per liter	0.28	0.38	0.30	0.41
2006	Per liter of petroleum fuel equivalent	0.38	0.49	0.45	0.57
2006–2012	Per liter of petroleum fuel equivalent	0.38	0.52	0.33	0.45

Source: Koplow (2006)

A3.26 Under the Caribbean Basin Initiative (CBI), countries in Central America and the Caribbean have had duty-free access to the United States since 1989. The U.S.-Central America Free Trade Agreement (CAFTA) does not increase overall access to the U.S. ethanol market but simply establishes country-specific shares for El Salvador and Costa Rica within the existing CBI quota without increasing the overall quota size. Other CAFTA countries retain existing CBI benefits on ethanol. The country-specific shares for Costa Rica and El Salvador have the effect of limiting the overall CBI quota available to other Caribbean and Central American countries.

Argentina

A3.27 In April 2006, the government passed a bill requiring that gasoline and diesel contain 5 percent biofuel by 2010. It also provides fiscal incentives by means of tax exemption for biofuels and other different tax incentives. A number of firms—Repsol YFP, Mitsui Argentina, Terminal Puerto Rosario, Vicentín, Oil Fox and Cargill—have announced plans to invest in biofuel plants.

A3.28 Argentina is a leading low-cost producer of soybeans. The country's soybean production as well as exports nearly tripled in the 10-year period between 1993 and 2002. Its maize production has also been rising sharply (USDA 2001). More than 95 percent of soybean production is exported. Oilseeds and oilseed products, as well as many other agricultural products, are assessed export taxes. Soybeans are assessed a 27.5 percent export tax (raised from 23.5 percent in January 2007) and producer prices are automatically discounted by the same percentage, lowering the domestic soybean price.

Meals and oils are assessed a 24 percent export tax (raised from 20 percent in January 2007), also lowering domestic prices by the same percentage. Biodiesel, in contrast, carries an export tax of 5 percent, giving incentives to export biodiesel rather than oilseeds or oilseed products. The export tax is eliminated if a biodiesel blend is exported. In March 2007, the European Biodiesel Board complained to the European Commission that these differential export taxes create a 19–24 percent incentive given to the Argentinean biodiesel industry to process vegetable oils into biodiesel and export it (EBB 2007b). In December 2006, the government announced that Argentina would have the capacity to produce 2.5 million tonnes of biodiesel and ethanol by January 2010, of which nearly 1.7 million tonnes would be available for export (*Dow Jones International News* 2006b).

A3.29 As of April 2007, 17 ethanol producers had produced 204 million liters of ethanol from sugar cane in the marketing year 2007, about half for export and the remaining half for domestic consumption (USDA 2007i). Argentina is arguably the world's lowest-cost producer of maize. The government levies a 20 percent export tax on maize, but no tax on ethanol exports. As with biodiesel, this export tax structure provides an incentive to convert surplus maize to ethanol for export. Recent rises in world maize prices, however, have led to a sharp increase in maize exports, prompting the government to close the maize export registry in mid-November 2006 to ensure adequate supplies on the domestic market (USDA 2007f).

A3.30 The government exercises tight control over domestic gasoline and diesel prices and has not permitted recent rises in international petroleum prices to be passed through to the domestic market. This is achieved largely through levying a high export tax on petroleum oil, 45 percent applying above US$45 a barrel. Domestic gasoline and diesel prices essentially remained unchanged between January 2004 and February 2006, when international gasoline prices (as measured in the U.S. Gulf Coast) rose by 55 percent and diesel prices by 85 percent (ESMAP 2006). A pricing policy of keeping domestic petroleum fuel prices low poses a challenge for launching a sustainable and viable domestic biofuel market.

Australia

A3.31 Australia has set a target of increasing annual biofuel production to 350 million liters by 2010. Although the target was originally announced as part of the government's 2001 election commitment, the country's fuel ethanol program has encountered a number of obstacles, notably low consumer confidence (ESMAP 2005). Ethanol-blended gasoline has reportedly been sold mostly at independent outlets and less at the outlets of the four major oil companies (*Courier Mail* 2007). Domestic fuel ethanol production rose by more than 50 percent from about 23 million liters in 2004–2005 to 36 million liters by the end of June 2006. The government's support for biofuel production has included more than A$37 million (US$28 million) in capital grants, A$52 million (US$39 million) in ethanol production grants, the introduction of an E10 label of assurance on all locally built vehicles, and, most importantly, fuel-tax exemption (*Platts Commodity News* 2006). Ethanol produced is from wheat, waste starch, and molasses. Ethanol production based on sugar cane uses only the poorest-grade molasses not suitable for crystal sugar production; molasses-based ethanol does not represent a large share of ethanol production. Ethanol production using sorghum and winter cereals is expected to provide most of the growth in ethanol production. One concern is the possibility of a significant domestic grain shortage in the coming decade; prolonged periods of drought are not uncommon in Australia. Biodiesel became available in commercial quantities in 2006. One plant with an annual production capacity of 140 million liters uses palm oil imported from Indonesia and Malaysia.

A3.32 In September 2002, the government announced that both gasoline and ethanol blended with gasoline would attract an excise tax rate of A$0.38143 (US$0.21 at the time, US$0.31 as of April 2007) per liter. Imported ethanol would attract customs duty at the same rate. A subsidy of A$0.38143 per liter would be provided to domestic ethanol producers, offsetting the excise tax and giving a cost-advantage of A$0.38143 per liter over imported ethanol. The producer grant would be in effect until June 2011. In September 2003, the government similarly announced that both diesel and biodiesel locally manufactured for automotive use would attract an excise rate of A$0.38143 per liter. Imported biodiesel would attract customs duty at the same rate. Unlike ethanol, however, a subsidy of A$0.38143 per liter would be given until June 2011 for the production *and importation* of eligible biodiesel. As such, domestically produced biodiesel does not enjoy a tax advantage over imports. The grant will be progressively phased out from July 2011 to June 2015 (Australian Taxation Office 2006a and 2006b).

A3.33 In December 2003, the government announced a new schedule for automotive fuel tax. The new schedule placed the fuel tax on an energy-content basis with four fuel tax bands. Gasoline and both diesel and biodiesel belong to the high energy content band and will be taxed at A$0.38143 per liter, whereas ethanol belongs to a mid-energy content band and will be taxed at A$0.25 (US$0.21) per liter. The final fuel tax rates in 2015 (net of grants) will be A$0.125 (US$0.10) per liter for fuel ethanol and A$0.191 (US$0.16) per liter for biodiesel in 2015—a 50 percent discount to the energy content fuel tax rates (Biofuels Taskforce 2005). The tax advantage on a per liter basis will be A$0.25643 (US$0.21) for ethanol relative to gasoline and A$0.19043 (US$0.16) for biodiesel relative to diesel.

Canada

A3.34 Canada's biofuel industry began in the 1980s. Ethanol production in 2005 was 240 million liters. There is little production of biodiesel at present. Government support has been in the form of tax reductions and project financing (see Littman forthcoming for more detail).

A3.35 In 1992, the federal government granted an excise-tax exemption of C$0.085 (US$0.07 using the exchange rate in 1992) per liter of ethanol made from biomass and used in gasoline. This was increased to C$0.10 (US$0.09) per liter of ethanol blended in 1995. By the mid-1990s, several provincial governments had granted exemptions from provincial excise taxes for ethanol. Out of 13 provinces, six provide biofuel subsidies. Manitoba, Ontario, and Saskatchewan have mandatory blending requirements for ethanol in gasoline. Manitoba and Saskatchewan offer a provincial fuel tax reduction for ethanol produced in their own provinces. Quebec bases its tax credit on the price of West Texas Intermediate crude, reducing the tax credit to zero when the crude oil price reaches US$65 per barrel.

A3.36 Between 1999 and 2005, the National Biomass Ethanol Program created a guaranteed repayable line of credit of C$70 million (US$62 million). The program was extended in 2003 to end-March 2006, increasing the total credit limit to C$135 million (US$120 million). The government announced an Ethanol Expansion Program in August 2003, in which it offered up to C$100 million (US$89 million) in repayable contributions toward the construction of fuel ethanol production facilities in Canada. In the two rounds under the Ethanol Expansion Program, a total of C$124 million (US$110 million) was allocated.

A3.37 The federal government's "Climate Change Action Plan 2000" included a target to enable 25 percent of Canada's total gasoline supply to contain up to 10 percent ethanol. The 2002 Climate Change Action Plan increased the percentage of total gasoline supply containing 10 percent ethanol to a minimum of 35 percent of the total supply. More recently, the government has expressed a desire for 5 percent of Canada's transport fuel to be renewable. Gasoline and diesel consumption in 2005 was 38 billion and 16 billion liters, respectively. A 5 percent target would have required more than 1.9 billion liters of ethanol (after taking into account ethanol's lower energy content) and 0.8 billion liters of biodiesel, requiring an order-of-magnitude increase in biofuel production.

A3.38 In December 2006, Environment Minister Rona Ambrose announced the government's plan to pursue regulations under the Canadian Environmental Protection Act that that would require blending of 5 percent ethanol in gasoline by 2010 and 2 percent biodiesel in diesel fuel and heating oil by 2012, subject to verification through testing that the blended biodiesel fuel is safe and effective for Canadian climate and conditions. She added that the regulations would take at least two years to develop and that the government would hold consultation with provinces, territories, affected sectors, and other stakeholders in the design and implementation of regulations. The government in the same month also announced an investment of C$345 million (US$300 million) to help producers capture new opportunities in biofuels. In addition, the budget for fiscal year 2007 has allocated C$2 billion (US$1.8 billion) over seven years to support the production of renewable fuels.

A3.39 Canada imposes an import tariff of C$0.0492 (US$0.043) per liter of ethanol from countries with most-favored nation status (C$0.1228 per liter otherwise). The corresponding tariff on biodiesel is C$0.11 (US$0.10) per liter. There is no tariff on imports from countries with which Canada has a free trade agreement, such as NAFTA, and with which Canada has special tariff treatment agreements—Commonwealth Caribbean Countries tariff treatment, Least Developed Country tariff treatment, General Preferential tariff treatment, Chile tariff, and Costa Rica tariff.

Colombia

A3.40 Colombia is a net petroleum oil exporter, but its oil production has been declining steadily since 1999. The country exports about half of its crude oil production. Colombia is also an exporter of sugar. In September 2001, the government approved a law requiring cities in Colombia with populations exceeding 500,000 to add 10 percent ethanol to gasoline beginning in 2006. Fuel ethanol is exempt from the value added tax and several other levies. Current ethanol production capacity is 1.1 million liters per day and five ethanol plants owned by major sugar producers supply an estimated 60 percent of the total needs to comply with the requirement to blend 10 percent ethanol into gasoline. Investments for the remaining 40 percent have not yet started (USDA 2007g).

A3.41 The new requirements for use of ethanol are having a major impact on domestic sugar production and exports. Sugar cane needed for this purpose could reach the equivalent of half what is currently used for exports. Colombia's sugar production fell by approximately 0.3 million tonnes to 2.4 million tonnes in marketing year 2005–06 due to diversion of sugar cane for ethanol production, and is expected to rise only slightly in 2006–07. Sugar exports correspondingly declined 20 percent to 988,000 tonnes while imports reached 116,000 tonnes in 2005–06 (USDA 2007g).

A3.42 The sugar industry enjoys protection from the government. A government decree issued in October 2003 exempts areas newly planted with sugar cane from taxes for the next 14 years. Sugar cane production receives credit from a government institution, which subsidizes the credit by forgiving up to 40 percent of the principal. The government also provides support to sugar exports (USDA 2007g).

A3.43 Colombia is the largest palm oil producer in Latin America, although its output is only 4 percent of that of Malaysia. There are plans to start biodiesel production. A plan announced in mid-2006 to construct a biodiesel plant indicated that the bulk of the biodiesel would be exported to Spain (Latin American News Digest 2006). In April 2007, Colombian state-owned petroleum company Ecopetrol, jointly with local palm oil producers, reportedly announced that it would invest US$23 million in a new biodiesel plant. The plant, scheduled to come on stream in mid-2008, will have an annual production capacity of 100,000 tonnes of biodiesel, which will be blended into petroleum diesel at 2 percent (Latin American News Digest 2007). Colombia appears to impose an ad valorem tariff rate of 15 percent on ethanol and 10 percent on biodiesel (TIC 2006).

Indonesia

A3.44 Although Indonesia is a major petroleum producer, it became a net petroleum oil importer for the first time in 2004. Domestic petroleum product prices have historically been considerably lower than international market prices, leading to widespread smuggling of subsidized fuels out of the country and increasing apparent consumption. The fuel subsidy bill in 2005 was close to US$10 billion. Although domestic fuel prices in 2005 were more than doubled and, for kerosene, tripled, they remain below international levels, posing a budgetary burden. Based on an assumed world crude oil price of US$57 per barrel, the government allocated Rp54 trillion (US$6 billion) to fuel subsidies in 2006. The government is focusing on reducing demand and fuel switching to cope with the large fuel subsidy bill (ESMAP 2006).

A3.45 One of the government's strategies for reducing consumption of subsidized petroleum fuels is to switch to biofuels. Indonesia and Malaysia produce about 15 million tonnes of palm oil each and account for 85 percent of global production (USDA 2006m). Compared to Malaysia, Indonesia has considerable unutilized land left that is suited for growing palm. As such, it is in a position to become a leading biodiesel producer. In April 2006, the government issued regulations allowing blending of 10 percent ethanol in gasoline and 10 percent biodiesel in diesel fuel, effective from the previous month. In July 2006, the Minister of Energy and Mineral Resources announced that the country required an investment of 200 trillion rupiah (US$22 billion) in order to produce biofuels to reduce subsidized petroleum product consumption by 10 percent by 2010. The Minister also announced that Indonesia planned to build 11 biodiesel plants and that a special fund for the development of alternative energy would be used to pay for the plants (Agence France Presse 2006). In 2006, the government also announced a plan to develop up to 1.8 million hectares of land for new palm oil plantations and to use the new production for biodiesel while maintaining the existing production for cooking oil. This plan, however, has encountered implementation difficulties (USDA 2007e).

A3.46 In January 2007, 67 agreements were signed by 52 foreign, local, and state-owned enterprises under the Joint Initiative for Biofuel Development. The contract values were estimated to be US$12.4 billion; the financing would be supported by the government's bank interest subsidy program. As of that time, two firms were producing biodiesel from palm oil and selling it to Pertamina for blending into petroleum diesel for local consumption. A few other firms were producing biodiesel on a small-scale for their own consumption. One facility under construction will have an annual capacity of 350,000 tonnes (USDA 2007e). There were also two firms producing ethanol. Indonesia's subsidized domestic diesel price is likely to pose a challenge to establishing a commercially viable domestic biodiesel industry. Indonesia could become a world leader in biodiesel exports, depending on the movement of world palm oil prices and how questions about the environmental sustainability of palm cultivation are addressed. By the end of 2007, according to announced plans for plant expansion and new construction, the annual capacity for biodiesel production could increase to nearly 2.5 million tonnes from approximately 300,000 tonnes at the beginning of the year (USDA 2007b).

Japan

A3.47 There is little production of biofuel in Japan. This may change if technologies for cellulosic ethanol and other alternative feedstocks become commercially viable. Japan's interest in biofuels stems primarily from the government's desire to reduce lifecycle GHG emissions in the transport sector to help meet Kyoto protocol targets. In April 2005, the Japanese cabinet committed to consuming 500 million liters of crude equivalent of biofuel in fiscal 2010. In 2003, the government began allowing ethanol blending in gasoline at 3 percent, but biofuel consumption has remained negligibly small, in part because of a lack of fiscal incentives. It was reported in 2006 that the government would introduce a new tax incentive for blending ethanol into gasoline in fiscal year 2007–08 (April–March) (USDA 2006f). The country's Quality Assurance Act was amended in March 2007 to permit blending up to 5 percent biodiesel in petroleum diesel.

A3.48 The Ministry of Environment has set a long-term goal of achieving 10 percent biofuel in total automotive fuel consumption by 2030. To assist in meeting this target, the ministry requires that all new gasoline-engined cars registered in Japan from

2010 be capable of running on E10, by which date a target has been set for 40 percent of all such vehicles on Japanese roads to be E10 compatible.

A3.49 Instead of blending ethanol, the Petroleum Association of Japan plans to blend ETBE, and set a target of using 360 million liters of ethanol (against total gasoline consumption of about 60 billion liters) to blend 8 percent ETBE in some gasoline by 2010. One advantage of this strategy is that ETBE can be blended at the refinery. To this end, the Association will be importing ethanol and ETBE. Japan levies high import duties on fuel ethanol. The import duty was 23.8 percent in fiscal year 2006–07, and will decline each year until it is lowered to 10 percent in 2010. The import duty on crude oil is 0.16 yen a liter (US$0.23 a barrel) (USDA 2006f). The duty on biodiesel appears to be 4.6 percent (TIC 2006).

People's Republic of China

A3.50 China is the second largest petroleum oil consumer in the world after the United States. It is a large crude oil producer but needs to import about 40 percent of its petroleum consumption. The country's net import status and concerns about rapidly growing demand for energy are driving the government to seek alternative indigenous sources of energy. China is the world's third largest producer of fuel ethanol after the United States and Brazil, and, according to the government, 20 percent of all gasoline sold now contains ethanol. Biodiesel is still in the very early phases of testing and development.

A3.51 Ethanol is made mostly from maize; other feedstocks include cassava, sugar cane, and, on a trial basis, sorghum. Fuel ethanol production in 2005 was 920,000 tonnes (1.2 billion liters); maize was used as a feedstock for 80 percent of fuel ethanol production (USDA 2006n). Five provinces as well as 27 cities in another four provinces have been selling only gasohol since 2004 (Dow Jones Energy Service 2006). Concerns for food security have led China to import Thai tapioca for ethanol production (Reuters News 2006a), and the government to restrict production of ethanol from maize at the end of 2006. Ethanol exports surged from 138,000 tonnes in 2005 to 865,000 tonnes in 2006. Fearing domestic grain shortages, the government eliminated the rebate on the 13 percent value added tax in January 2007 (USDA 2007d).

A3.52 Subsidies of 1,373 yuan ($US172) per tonne of ethanol (US$0.14 per liter) are given to ethanol producers (USDA 2006n). Gasoline and diesel prices are controlled by the government and are set below world prices. Concerns about rising fuel prices have repeatedly delayed implementation of the government's plan to introduce fuel excise taxes, precluding fuel excise tax reduction as a biofuel support measure. Incentives for ethanol are granted through exempting the 5 percent consumption tax on ethanol, guaranteeing a profit of 100 yuan per tonne of ethanol (US$0.01 per liter), and setting the price of E10 at 91.11 percent of the shipping price of 90 RON gasoline (USDA 2006n). The government's "11th Five-Year Program" (2006–2011) targets fuel ethanol for expansion and renewable fuels from biomass for substantial support (Asia Pulse 2006). Significant ethanol plant construction is currently under way or planned. In November 2006, the government announced further subsidies and tax breaks for both biofuel producers and farmers who grow feedstocks other than grains. The additional incentives for biofuel producers will be provided when world oil prices fall below a threshold level (Reuters News 2006e). In December 2006, the government announced that biodiesel made from animal fat or vegetable oil is not subject to consumption tax (*Xinhua Business Weekly* 2006). For the foreseeable future, the biofuel program in China will be determined by government policy rather than economics. China levies an import tariff of 30 percent on ethanol (USDA 2006n).

Thailand

A3.53 Thailand produces enough crude oil and condensates to satisfy just one-quarter of its petroleum consumption. Rising petroleum prices have strengthened the government's resolve to reduce dependence on imported petroleum oil. Ethanol in Thailand is made mainly from molasses and cassava. Seven out of 43 approved ethanol plants are in operation and producing about 900,000 liters a day, far in excess of daily ethanol demand of 400,000 liters (USDA 2007h). The government actively promotes ethanol by maintaining a consistent price difference between E10 and gasoline of the same octane grade. The price difference more than compensates for the slightly lower fuel economy of E10, prompting E10 consumption to increase 23-fold in 2004 and 11-fold in 2005 (EPPO 2006). However, consumption has been relatively flat since early 2006, resulting in supply far exceeding demand by 2007 (*Price Oilgram Price Report* 2007). Until February 2007, the price difference was 1.5 baht (US$0.043) per liter for E10 and premium gasoline, both with a research octane number (RON) of 95. The price difference is achieved by lowering taxes and levies on E10, amounting to a difference of 2.47 baht per liter of E10 in late April 2006—corresponding to 24.7 baht (US$0.65) per liter of ethanol—a very large fiscal concession by any measure. In February and March 2007, in the face of a surplus of ethanol, the government increased the price difference three times in an attempt to make E10 more attractive, widening it to 2.5 baht (US$0.071) by mid-March. The government earlier planned to phase out 95 RON gasoline in January 2007 and to replace it entirely with 95 RON gasohol. However, concerns about compatibility of E10 with older vehicles prompted the government to postpone the phaseout date. The government has also announced that, as soon as the phaseout of 95 RON gasoline is complete, the price of gasohol will be raised by 2.5 baht per liter (Thai News Service 2006).

A3.54 Until February 2007, ethanol prices were negotiated between ethanol producers and petroleum companies and were set for a few months at a time. Unlike in Brazil, ethanol producers purchase molasses, forfeiting the benefit of using bagasse for energy generation or adjusting the sugar-ethanol production split on the basis of relative market prices. Local molasses and cassava prices have risen sharply in recent years, making ethanol economics unfavorable. In 2006, domestic prices of molasses rose to 4,000 baht (US$104) per tonne. Prices have fallen to 2,500 baht (US$70) per tonne in 2007, and are expected to remain at that level in 2007 and 2008 (USDA 2007h). One ethanol producer stopped plant operation in January 2006 on the grounds that the negotiated price in effect at the time was too low and that the company could no longer sustain financial losses (*Dow Jones International News* 2006a). In April 2006, a new price (exclusive of fuel taxes and fees) of 23 baht (US$0.60) per liter was negotiated.

This corresponded to US$0.75 per liter of gasoline equivalent, far in excess of the benchmark premium gasoline price in the region (Singapore) of US$0.51 per liter at the time. The price was subsequently renegotiated and raised to 25.30 baht (US$0.66) per liter, or US$0.83 per liter of gasoline equivalent, double premium gasoline prices in Singapore of US$0.39 in October 2006. In February 2007, Thailand adopted a new ethanol pricing formula, pegging domestic ethanol prices to prices on the Brazilian Commodity Exchange and including other components such as insurance and transportation costs. The new pricing policy was reported to have the effect of bringing down the price of ethanol from 25.30 baht (US$0.71 at the exchange rate prevailing in February 2007) to 19.33 baht (US$0.54) per liter (*Platts Commodity News* 2007).

A3.55 The government is also promoting the production and use of biodiesel from palm oil and other feedstocks. The government earlier promoted a plan to expand palm oil plantation significantly to make biodiesel. However, the government withdrew this plan in October 2006, stating that, with falling world crude oil prices, palm oil cost more than diesel on a volume basis and it would not make economic sense to subsidize a palm-based biodiesel project, started two years earlier and not taken up by farmers (Reuters News 2006c).

A3.56 Although Thai sugarcane production is competitive, the government provides price support. The support price for sugarcane at the beginning of 2006 was 800 baht (US$20) per tonne. There are two ethanol plants based on sugarcane and molasses. Unlike Brazil, domestic sugarcane supplies area available only four months a year.

A3.57 Thailand imposes a specific tariff of 2.5 baht per liter on ethanol. The import tariff was waived in 2005 when inadequate local supply necessitated ethanol imports, but the waiver expired on January 31, 2006. An ad valorem import tariff of 5 percent is levied on biodiesel.

References

AE Brazil. 2006. "Brazil's govt postpones decision on sugarcane loan increase." February 24.

AFX Asia. 2006a. "Malaysia's biofuel Envo Diesel stirs concern over possible engine damage." September 7.

———. 2006b. "Malaysia approves 75 biodiesel projects worth 7.01 bln rgt – minister." December 5.

Agence France Presse. 2006. "Indonesia to build 11 biodiesel plants." July 3.

Aksoy, M. Ataman, and John C. Beghin, eds. 2005. *Global Agricultural Trade and Developing Countries*. Washington, DC: World Bank.

Anderson, Kym, Harry de Gorter, and Will Martin. 2005. "Market Access Barriers in Agriculture and Options for Reform." In *Trade, Doha, and Development: A Window into the Issues*, ed. Richard Newfarmer, chapter 6. Washington, DC: World Bank.

Anderson, Kym, Will Martin, and Ernesto Valenzuela. 2006. "The Relative Importance of Global Agricultural Subsidies and Market Access." *World Trade Review* 5(3): 357–376.

Anderson, Kym, Will Martin, and Dominique van der Mensbruggher. 2006. "Doha Merchandise Trade Reform: What Is At Stake for Developing Countries?" *World Bank Economic Review* 20(2): 169–195.

ANFAVEA (Associação Nacional dos Fabricantes de Veículos Automotores). 2007. "Domestic sales in 2006." www.anfavea.com.br/tabelas2006.html.

Armstrong, A.P., J. Baro, J. Dartoy, A.P. Groves, J. Nikkonen, D.J. Rickeard, N.D. Thompson, and J-F Larivé. 2002. "Energy and Greenhouse Gas Balance of Biofuels for Europe—An Update." CONCAWE Report No. 2/02, April. Brussels: Concawe. www.est.org.uk/cd/data/Library/Technical/Multi-fuel%20studies/Energy_&_Greenhouse_Gas_Balance_of_Biofuels_in_Europe.pdf.

Asia Pulse. 2006. "Fuel ethanol enters rapid development stages in China." June 26.

Australian Taxation Office. 2006a. "An overview of excise on fuel ethanol." http://ato.gov.au/print.asp?doc=/content/52768.htm.

———. 2006b. "An overview of excise on biodiesel."

Automotive World. 2006. "Ethanol to consume over 20% of total corn yield in 2006." June 6.

Bacon, Robert. 2001. "Petroleum Taxes: Trends in Fuel Taxes (and Subsidies) and the Implications." Viewpoint Note Number 240, September. Washington, D.C.: World Bank. www.worldbank.org/html/fdp/notes/240/240summary.html.

Bannister, Geoffrey J., and Kamau Thugge. 2001. "International Trade and Poverty Alleviation." IMF Working Paper WP/01/54. Washington, DC: International Monetary Fund. www.imf.org/external/pubs/ft/wp/2001/wp0154.pdf.

Beer, Tom, Tim Grant, Geoff Morgan, Jack Lapszewicz, Peter Anyon, Jim Edwards, Peter Nelson, Harry Watson, and David Williams. 2001. "Comparison of Transport Fuels." Final Report (EV45A/2/F3C) submitted to the Australian Greenhouse Office on the Stage

2 study of Life-cycle Emissions Analysis of Alternative Fuels for Heavy Vehicles. www.greenhouse.gov.au/transport/comparison/.

Binswanger, Hans, Maw-Cheng Yang, Alan Bowers, and Yair Mundlak. 1987. "On the Determinants of Cross-Country Aggregate Agricultural Supply." *Journal of Econometrics* 36(1/2):111–131.

Biofuels Taskforce. 2005. "Report of the Biofuels Taskforce to the Prime Minister." Australian Government, August 2. www.dpmc.gov.au/biofuels/final_report.cfm.

BNAmericas Oil & Gas News. 2006. "Petrobras prepares to export 850 M liters of ethanol in 2007." July 6.

Business Standard. 2006. "Ethanol pricing talks fall through (as ethanol manufacturers have asked the price to be revised to Rs27.83 per litre from Rs18.75 per litre)." August 12.

Business Times. 2006. "India's rollback of palm oil base import prices sows confusion." August 17.

Byerlee, Derk and Ruben Echeverria, eds. 2002. *Agricultural Research Policy in an Era of Privatization*. Cambridge, Massachusetts: CABI Publishing

CBEC (Central Board of Excise and Customs, Government of India). 2006. "Customs Tariff 2006–07." www.cbec.gov.in/cae/customs/cst-0607/cst-main.htm.

CBO (Congressional Budget Office). 2005. "Policies that Distort World Agricultural Trade: Prevalence and Magnitude." August. www.cbo.gov/ftpdocs/66xx/doc6614/08-22-Doha.pdf.

Commission of the European Communities. 2005. "Communication from the Commission. Biomass Action Plan." COM(2005) 628 final. Brussels, December 7. http://ec.europa.eu/energy/res/biomass_action_plan/doc/2005_12_07_comm_biomass_action_plan_en.pdf.

———. 2006a. "Communication from the Commission. An EU Strategy for Biofuels." COM(2006) 34 final. Brussels, February 8. http://ec.europa.eu/comm/agriculture/biomass/biofuel/com2006_34_en.pdf.

———. 2006b. "Commission Staff Working Document. Annex to the Communication from the Commission. An EU Strategy for Biofuels. Impact Assessment." http://ec.europa.eu/comm/agriculture/biomass/biofuel/sec2006_142_en.pdf.

The Courier Mail. 2007. "Oil giants short of biofuel target." April 19.

CRS (Congressional Research Service). 2000. "Agricultural Marketing Assistance Loans and Loan Deficiency Payments." 98–744 ENR, December 13. http://ncseonline.org/nle/crsreports/agriculture/ag-59.cfm.

———. 2006a. "Fuel Ethanol: Background and Public Policy Issues." RL33290, March 3. www.khoslaventures.com/presentations/Fuel_Ethanol.pdf.

———. 2006b. "European Union Biofuels Policy and Agriculture: An Overview." RS22404, March 16. www.ncseonline.org/NLE/CRSreports/06Apr/RS22404.pdf.

Delucchi, Mark A. 2003. "A Lifecycle Emissions Model (LEM): Lifecycle Emissions from Transportation Fuels, Motor Vehicles, Transportation Modes, Electricity Use, Heating and Cooking Fuels, and Materials. Documentation of Methods and Data." UCT-ITS-RR-03-17 Main Report, Institute of Transportation Studies, University of California Davis. December. www.its.ucdavis.edu/publications/2003/UCD-ITS-RR-03-17-MAIN.pdf.

Diao, xinshen, Agapi Somwaru, and Terry Roe. 2001. "A Global Analysis of Agricultural Reform in WTP Member Countries." In Agricultural Policy Reform in WTO—The Road Ahead, ed. Mary E. Burfisher, chapter 1. Washington, D.C.: Economic Research Service, U.S. Department of Agriculture. www.ers.usda.gov/Publications/aer802/.

Dow Jones Commodities Service. 2006. "Brazil's Rio state lowers taxes to court sugarcane prod." February 15.

———. 2007a. "Crude oil weakness may drag down palm oil." January 3.

———. 2007b. "India co building 250,000 tons/yr biodiesel unit." January 9.

———. 2007c. "US remains main buyer of Brazil's ethanol exports in January." February 12.

———. 2007d. "World 06–07 sugar output seen at 160M tons—F.O. Licht." February 12.

———. 2007e. "India edible oil prices mixed on import duty cut." April 20.

Dow Jones Energy Service. 2006. "Ethanol-blended gasoline 20% of China's gasoline demand." March 2.

Dow Jones International News. 2006a. "Ethanol producers seek higher prices." February 19.

———. 2006b. "Argentina biofuel capacity to hit 2.5M tons in 2010-report." December 26.

———. 2007a. "80% of Brazil ethanol seen needed for local mkt rhru '13." March 2.

———. 2007b. "EU purchases of Brazil fuel ethanol seen rising in 07." March 15.

———. 2007c. "Brazil Rio mulls 5% biodiesel mix via used kitchen oil." April 20.

EBB (European Biodiesel Board). 2007a. "Statistics. The EU biodiesel industry." www.ebb-eu.org/stats.php.

———. 2007b. "Re: International trade of biodiesel—unfair competition from 'B99' subsidized exports from US and Argentinean Differential Export Taxes (DETs)." March 19. www.ebb-eu.org/EBBpressreleases/let%20to%20CM%20Mandelson%20unfair%20B99%20and%20DETs.pdf.

Ebio (European Bioethanol Fuel Association). 2007. "Production data." www.ebio.org/production_data_pd.php.

EIA (Energy Information Administration). 2006. "Petroleum Marketing Monthly September 2006." www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/current/pdf/pmmall.pdf,

Elobeid, Amani, and Simla Tokgoz. 2006. "Removal of U.S. Ethanol Domestic and Trade Distortions: Impact on U.S. and Brazilian Ethanol Markets." Working Paper 06-WP 427. Ames, Iowa: Iowa State University. www.card.iastate.edu/publications/DBS/PDFFiles/06wp427.pdf.

Energy Economist. 2007. "Palm oil giants focus on biofuels." January 1.

Energy Intelligence. 2007. "Prices: Northwest Europe."

EnergyResource. 2006. "Biodiesel backlash: market for synthetic glycerin is plummeting." July 26.

Energy Washington Week. 2006a. "Escape hatch in ethanol duty policy may be challenged in Senate." September 6.

———. 2006b. "Traders may be gaming biodiesel incentive through re-exporting." November 8.

EPPO (Energy Planning and Policy Office). 2006. Energy database. www.eppo.go.th/info/index.html#1.

ESMAP. 2005. "The Potential for Biofuels for Transport in Developing Countries." Report 312/05, October. Washington, DC: World Bank. http://wbln0018.worldbank.org/esmap/site.nsf/files/312-05+Biofuels+for_Web.pdf/US$FILE/312-05+Biofuels+for_Web.pdf.

———. 2006. "Coping with Higher Oil Prices." Report 323/06. Washington, DC: World Bank. http://wbln0018.worldbank.org/esmap/site.nsf/pages/Enhanced+2006.

Espadas, Tanya Loretta. 1994. "Implications of Transportation Costs in Relation to Soybeans and Related Products: A Comparison of South Carolina, United States, and Sao Paulo, Brazil." M.S. thesis, Clemson University, August.

European Commission. 2005. "EU radically reforms its sugar sector to give producers long-term competitive future." Press Release of European Commission on sugar policy, IP/05/1473, Brussels, November 24. http://europa.eu.int/rapid/pressReleasesAction.do?reference=IP/05/1473&format=HTML&aged=0&language=EN&guiLanguage=en.

EU (European Union). 2003a. "Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the Promotion of the Use of Biofuels or Other Renewable Fuels for Transport." *Official Journal of the European Union*. L 123/42. http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_123/l_12320030517en00420046.pdf.

———. 2003b. "Council Directive 2003/96/EC of 27 October 2003 "Restructuring the Community Framework for the Taxation of Energy Products and Electricity." *Official Journal of the European Union*. L 283/51. http://europa.eu/eur-lex/pri/en/oj/dat/2003/l_283/l_28320031031en00510070.pdf

Evenson, Robert E. 2001. "Economic impacts of agricultural research and extension." In *Handbook of Agricultural Economics*, eds. B. L. Gardner and G. C. Rausser, chapter 11. Amsterdam: Elsevier B.V. www.sciencedirect.com/science/article/B7P5B-4FPWV0B-1H/2/dd30bd49aa69dd46c001d606e0b9b472

Fabiosa, Jay, John Beghin, Stephane de Cara, Cheng Fang, Murat Isik, and Holger Matthey. 2003. "Agricultural Market Liberalization and the Doha Round." Proceedings of the 25th International Conference of Agricultural Economics, Durban, South Africa, August 16–22.

FAO (Food and Agriculture Organization). 2003. The State of Food Insecurity in the World 2003. Rome: FAO. ftp://ftp.fao.org/docrep/fao/006/j0083e/j0083e00.pdf.

FAPRI (Food and Agricultural Policy Research Institute). 2006. "FAPRI 2006 U.S. and World Agricultural Outlook." Staff Report. Iowa State University and University of Missouri-Columbia, Ames, Iowa. www.fapri.org/outlook2006/text/OutlookPub2006.pdf.

———. 2007. "FAPRI 2007 World Agricultural Outlook." Staff Report. Iowa State University and University of Missouri-Columbia, Ames, Iowa.

Financial Times. 2007. "Producers worldwide face up to 'nightmare'." February 23.

Financial Times Asia Africa Intelligence Wire. 2006. "Financial Express: The failed economics of bio-fuels." April 14.

FindLaw. Undated. "U.S. Supreme Court, New Energy Co. of Indiana v. Limbach, 486 U.S. 269 (1988)." http://caselaw.lp.findlaw.com/scripts/printer_friendly.pl?page=us/486/269.html.

Gallagher, Paul, Guenter Schamel, Hosein Shapouri, and Heather Brubaker. 2006. “The International Competitiveness of the U.S. Corn-Ethanol Industry: A Comparison with Sugar-Ethanol Processing in Brazil.” *Agribusiness* 22(1):109–134.

Global Insight Daily Analysis. 2007. “Brazil predicts that biodiesel production could rise to 1.3 bil. liters per annum.” February 27.

Global Crop Diversity Trust. 2006. “Maize.” www.croptrust.org/main/priority.php?itemid=30.

Gwilliam, Ken, Robert Bacon, Masami Kojima, and Kseniya Lvovsky. 2001. “Transport Fuel Taxes and Urban Air Quality.” *Pollution Management in Focus Discussion Note Number 11*. Washington, DC: World Bank. http://lnweb18.worldbank.org/essd/envext.nsf/51ByDocName/DocumentsandPublicationsIn-FocusNotesDiscussionNote11TransportFuelTaxesandUrbanAirQualityDecember2001.

Hertel, T.W. and R. Keeney. 2006. “What’s at Stake: The Relative Importance of Import Barriers, Export Subsidies and Domestic Suppor.” In *Agricultural Trade Reform and the Doha Development Agenda*, eds. K. Anderson and W. Martin, chapter 2. London: Palgrave Macmillan and Washington, DC: World Bank.

IEA (International Energy Agency). 2006. *Energy Statistics*. Online edition. Paris.

Ingco, Merlinda D., and John D. Nash, eds. 2004. *Agriculture and the WTO: Creating a Trading System for Development*. Washington, DC: World Bank.

Iowa Legislature. 2006. “House File 2754 – Enrolled.” http://coolice.legis.state.ia.us/Cool-ICE/default.asp?Category=billinfo&Service=Billbook&frame=1&GA=81&hbill=HF2754.

IPC (International Food & Agricultural Trade Policy Council). 2005. “The US Farm Bill and the Doha Negotiations: On Parallel Tracks or a Collision Course?” An IPC Issues Brief 15, September. www.agritrade.org/Publications/IBs/329701.pdf.

JPEC (Japan Petroleum Energy Center). 2005. “A Study of Fuel Standards and Testing Methods for Biodiesel Fuel.” www.pecj.or.jp/japanese/division/division09/Japan-korea20050928/08_Revised_biodiesel.pdf.

Koplow, Doug. 2006. “Biofuels—At What Cost? Government support for ethanol and biodiesel in the United States.” Geneva, Switzerland: Global Subsidies Initiative of the International Institute for Sustainable Development. www.globalsubsidies.org/IMG/pdf/biofuels_subsidies_us.pdf.

Krivonos, Ekaterina, and Marcelo Olarreaga. 2006. “Sugar Prices, Labor Income, and Poverty in Brazil.” World Bank Policy Research Working Paper 3874, April. Washington, DC: World Bank. www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2006/04/13/000160016_20060413103321/Rendered/PDF/wps38740Replacement01paper0is0fine1.pdf.

Koizumi, Tatsuji, and Koji Yanagishima. 2005. “Impacts of the Brazilian Ethanol Program on the World Ethanol and Sugar Market: An Econometric Simulation Approach.” *Jpn. J. Rural Econ*. 7:61–77.

Krueger, Anne, M. Schiff, and A. Valdes. 1992. *The Political Economy of Agricultural Pricing Policy*. Baltimore: John Hopkins University Press.

Latin American News Digest. 2006. “Colombia Erpasa to start biodiesel production.” June 13.

———. 2007. "Colombian Ecopetrol, palm oil producers to invest $23 mln in biodiesel plant construction." April 23.

Kutas, Géraldine and Carina Lindberg. Forthcoming. "Government Support for Ethanol and Biodiesel in the European Union." Geneva, Switzerland: Global Subsidies Initiative of the International Institute for Sustainable Development.

Lipsey, R. G. and Kelvin Lancaster. 1956–57. "The General Theory of Second Best." *The Review of Economic Studies* 24(1):11–32.

Littman, Todd. Forthcoming. "Government Support for Ethanol and Biodiesel in Canada." Geneva, Switzerland: Global Subsidies Initiative of the International Institute for Sustainable Development.

LMC International. 2003. "Biodiesel: How Will It Affect the Fuel and Oilseeds Markets?"

———. 2006. "A Strategic Assessment of the Impact of Biofuel Demand for Agricultural Commodities."

Louisiana State Legislature. 2006. "Act No. 313." www.legis.state.la.us/billdata/streamdocument.asp?did=399857.

Macedo, Isaías de Carvalho, Manoel Regis Lima Verde Lea, and João Eduardo Azevedo Ramos da Silva. 2004. "Assessment of Greenhouse Gas Emissions in the Production and Use of Fuel Ethanol in Brazil." April. www.unica.com.br/i_pages/files/pdf_ingles.pdf.

Manila Bulletin. 2007. "RP can adopt technology from world's 1st comm'l sweet sorghum-based ethanol." October 15.

Manitoba Government. 2003. "Energy Initiative: Ethanol Blended Fuels." www.gov.mb.ca/est/energy/initiatives/ethanolfuels.html.

———. 2006. "Budget Paper D: Taxation Adjustments." www.gov.mb.ca/finance/budget06/papers/taxation.pdf.

Methanol Institute and International Fuel Quality Center. 2006. "A Biodiesel Primer: Market & Public Policy Developments, Quality, Standards & Handling." www.biodiesel.org/resources/reportsdatabase/reports/gen/20060401-GEN369.pdf.

Missouri General Assembly. 2006. "HB 1270." www.house.mo.gov/bills061/bills/hb1270.htm.

Mitchell, Donald. 2004. "Sugar Policies: Opportunity for Change." World Bank Policy Research Working Paper 3222, February. Washington, DC: World Bank. http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/06/01/000009486_20040601165704/Rendered/PDF/wps3222sugar.pdf.

Mitchell, Donald, and Jean-Charles Le Vallée. 2005. "International Food Price Variability: The Implications of Commodity Policy Changes." Paper presented at the World Bank-DfID Workshop, "Managing Food Price Risk and Instability." Washington, DC, February 28–March 1.

Montana State Legislature. 2005. "Senate Bill No. 293." http://data.opi.state.mt.us/bills/2005/BillPdf/SB0293.pdf.

Nardi, Matias Gabriel. 2006. "Competitiveness Analysis of Argentina, Brazil and United States in Soybean Production, Storage, Transportation, Crushing and Exporting to a Common Market." M.S. thesis, Clemson University, August.

NBD (National Biodiesel Board). 2006. “U.S. Biodiesel Production Capacity.” January 31. www.biodiesel.org/pdf_files/fuelfactsheets/Production_Capacity.pdf.

———. 2007. “Biodiesel Tax Advisory Notice, National Biodiesel Board.” April 25. www.biodiesel.org/resources/PR_supporting_docs/20070425_tax%20notice.pdf.

NMMA (National Marine Manufacturers’ Association). 2006. “Ethanol Blended Fuels.” www.nmma.org/lib/docs/nmma/gr/environmental/Ethanol_Blended_Fuels_-_MIC_Summaryv1.doc.

Nordic Business Report. 2006. “Second-generation biodiesel from Neste Oil to power buses and waste disposal trucks in Greater Helsinki.” October 20.

Novem (Netherlands Agency for Energy and Environment). 2003. “Conventional Bio-Transportation Fuels. An Update.” Report 2GAVE-03.10, May. www.ecn.nl/_files/bio/Report_2GAVE-03.10.pdf.

OECD (Organization for Economic Cooperation and Development). 2005. *Agricultural Policies in OECD Countries: Monitoring and Evaluation*. Paris: OECD Publications.

———. 2006a. “Agricultural Market Impacts of Future Growth in the Production of Biofuels.” AGR/CA/APM(2005)24/FINAL. Directorate for Food, Agriculture and Fisheries, Committee for Agriculture. Paris. www.oecd.org/dataoecd/58/62/36074135.pdf.

———. 2006b. *Agricultural Policies in OECD Countries: At a Glance*. Paris: OECD Publications.

———. 2006c. “Agricultural Policy and Trade Reform: Potential Effects at Global, National and Household Levels.” Paris. www.oecd.org/dataoecd/28/43/36884483.pdf.

OECD/Eurostat. 1999. “The Environmental Goods and Services Industry: Manual on Data Collection and Analysis.” Paris.

Petroleum Economist. 2006. “Canada abandons Kyoto.” December.

Planning Commission, Government of India. 2006. “Integrated Energy Policy: Report of the Expert Committee.” http://planningcommission.nic.in/reports/genrep/rep_intengy.pdf.

Platts Commodity News. 2006. “Australian ethanol output rises more than 50% in 2006: minister.” June 1.

———. 2007. “Thailand adopts new ethanol formula pegged to Brazilian prices.” February 5.

Platts Oilgram News. 2006. “Malaysia halts approval process on biodiesel plants.” August 2,

Platts Oilgram Price Report. 2007. “Thailand moves to boost use of E10 blend.” March 19.

Press Trust of India Limited. 2006. “Govt might give tax benefits, duty exemption on bio fuels.” October 23.

Rantanen, Leena, Raimo Linnaila, Päivi Aakko, and Tiina Harju. “NExBTL—Biodiesel fuel of the second generation.” SAE Technical Papers 2005-01-3771. Warrendale, Pennsylvania: SAE International. www.nesteoil.com/default.asp?path=1,41,535,547,3716,3884.

Reuters News. 2006a. “Thai tapioca surplus aimed at Chinese ethanol demand.” May 4.

———. 2006b. “Palm users wary of Malaysia, Indonesia moves.” July 25.

———. 2006c. “New Thai energy minister kills biodiesel plans.” October 19.

———. 2006d. “Three Malaysia biodiesel plants meet winter spec.” November 3.

———. 2006e. “China to offer tax break, subsidies on biofuel.” November 10.

———. 2007. "Sugar surplus sours fortunes of Indian mills." April 30.

RFA (Renewable Fuels Association). 2007. "Industry Statistics." www.ethanolrfa.org/industry/statistics/.

Ricardo, David. [1817] 1973. The *Principles of Political Economy and Taxation.* New York: Dutton.

Roseboom, Johannes. 2003. "Optimizing Investment in Agricultural Research, or the Quest for Prosperity." International Service for National Argricultural Research (ISNAR) Report 23. The Hague: ISNAR. ftp://ftp.cgiar.org/isnar/publicat/PDF/rr-23.pdf.

Runge, C. Ford, and Benjamin Senauer. 2007. "How Biofuels Could Starve the Poor." *Foreign Affairs* 86(3). www.foreignaffairs.org/20070501faessay86305/c-ford-runge-benjamin-senauer/how-biofuels-could-starve-the-poor.html.

Sheehan, John, Vince Camobreco, James Duffield, Michael Graboski, and Housein Shapouri. 1998. "An Overview of Biodiesel and Petroleum Diesel Life Cycles." National Renewable Energy Laboratory Report NREL/TP-580-24772, May. www.afdc.doe.gov/pdfs/3812.pdf.

Steenblik, Ronald. 2005a. "Environmental Goods: A Comparison of the APEC and OECD Lists." OECD Trade and Environment Working Paper, No. 2005–04. www.oecd.org/dataoecd/44/3/35837840.pdf.

———. 2005b. "Liberalizing Trade in 'Environmental Goods': Some Practical Considerations." OECD Trade and Environment Working Paper, No. 2005–05. Paris. www.oecd.org/dataoecd/25/8/35978987.pdf.

———. 2005c. "Liberalization of Trade in Renewable-Energy Products and Associated Goods: Charcoal, Solar Photovoltaic Systems, and Wind Pumps and Turbines." OECD Trade and Environment Working Paper, No. 2005–07. Paris. http://titania.sourceoecd.org/vl=9602043/cl=18/nw=1/rpsv/cgi-bin/wppdf?file=5l9zlxf7b334.pdf.

Szmrecsányi, Tamás, and Eduardo F.P. Moreira. 1992. "Brazilian Sugar and Ethanol: Fifty Years of Growth, Crisis and Modernization (1939–1989)." *Rivista di Storia Economica* 9(1–2): 95–111.

Thai News Service. 2006. "Plan to discontinue sale on octane 95 petrol indefinitely postponed." October 20.

TIC (Trade Information Center). 2006. "Tariff and tax information: Country and regional tariff and tax resources." www.ita.doc.gov/td/tic/tariff/country_tariff_info.htm.

UEPA (European Union of Ethanol Producers). 2005. "How to achieve the objectives and the benefits of the biofuel programme." www.uepa.be/newscontent.php?id=14.

UNCTAD (United Nations Conference on Trade and Development). 1995. "Environmentally Peferable Products (EPPs) as a Trade Opportunity for Developing Countries." UNCTAD/COM/70, December. Geneva.

U.S. Congress. 2004. "H.R. 4520." http://www.govtrack.us/data/us/bills.text/108/h/h4520.pdf.

———. 2005. "H.R. 6." www.er.doe.gov/bes/EPAct_2005_08AUG05.pdf.

USDA (United States Department of Agriculture). 2001. "Agriculture in Brazil and Argentina: Developments and Prospects for Major Crop Fields." Agriculture and Trade Report

WRS–01–3. Washington, DC: USDA. www.ers.usda.gov/publications/wrs013/wrs013.pdf.

———. 2002. “Corn: Policy.” Economic Research Service. http://www.ers.usda.gov/Briefing/Corn/policy.htm.

———. 2004. “Bioenergy Program.” www.fsa.usda.gov/pas/publications/facts/html/Bioenergy05.htm.

———. 2005a. “Brazil: Issues and Analysis.” Briefing Rooms, Economic Research Service, updated on May 6. http://www.ers.usda.gov/briefing/Brazil/domsupport.htm#table.

———. 2006a. “Agricultural Baseline Projections to 2015.” Office of the Chief Economist, World Agricultural Outlook Board. February. www.ers.usda.gov/publications/oce061/oce20061.pdf.

———. 2006b. “Brazil Sugar Ethanol Update.” GAIN Report BR6001, February 8. www.fas.usda.gov/gainfiles/200602/146176813.pdf.

———. 2006c. “Briefing Rooms: European Union.” Economic Research Service, updated on February 14. www.ers.usda.gov/Briefing/EuropeanUnion/.

———. 2006d. “India Sugar Annual 2006.” GAIN Report IN6029, April 10. www.fas.usda.gov/gainfiles/200604/146187388.pdf.

———. 2006e. “Brazil Oilseeds and Products: Annual Soybean Report 2006.” GAIN Report BR6610, May 1. www.fas.usda.gov/gainfiles/200605/146187635.pdf.

———. 2006f. “Japan Bio-Fuels. Bio-Fuels Production Report 2006.” GAIN Report, May 26. www.fas.usda.gov/gainfiles/200605/146197881.pdf.

———. 2006g. “Sweden. Bio-Fuels Annual 2006.” GAIN Report SW6013, June 1. www.fas.usda.gov/gainfiles/200606/146197886.pdf.

———. 2006h. “EU-25 Oilseeds and Products Annual 2006.” GAIN report E26092, June 11. www.fas.usda.gov/gainfiles/200606/146197961.pdf.

———. 2006i. “India Bio-Fuels Production Report 2006.” GAIN report IN6047, June 15. www.fas.usda.gov/gainfiles/200606/146197994.pdf.

———. 2006j. ““EU-25 Bio-Fuels. Biofuels Annual 2006.” GAIN Report E36102, July 11. www.fas.usda.gov/gainfiles/200702/146280256.pdf.

———. 2006k. “Brazil Oilseeds and Products: Two-year Moratorium on Soybeans from Deforested Areas of Amazon.” GAIN Report BR6620, July 25. www.fas.usda.gov/gainfiles/200607/146208449.pdf.

———. 2006l. “2007 Farm Bill Theme Paper: Energy and Agriculture.” August. www.usda.gov/documents/Farmbill07energy.pdf.

———. 2006m. “Oilseeds: World Markets and Trade.” August. www.fas.usda.gov/oilseeds/circular/2006/06-08/FULL06Aug.pdf.

———. 2006n. “China, People’s Republic of. Biofuels: An Alternative Future for Agriculture 2006.” GAIN Report CH6049, August 8. www.fas.usda.gov/gainfiles/200608/146208611.pdf.

———. 2007a. "USDA Agricultural Projections to 2016." Office of the Chief Economist, World Agricultural Outlook Board. February. www.ers.usda.gov/publications/oce071/oce20071.pdf.

———. 2007b. "Indonesia. Biofuels: Indonesian Biofuel Set to Take Off?" GAIN Report ID7004. www.fas.usda.gov/gainfiles/200701/146280036.pdf.

———. 2007c. "Brazil Oilseeds and Products: Soybean Update 2007." GAIN Report BR7603, February 2. www.fas.usda.gov/gainfiles/200702/146280122.pdf.

———. 2007d. "China, People's Republic of. Grain and Feed Annual 2007." GAIN Report CH7015, March 1. www.fas.usda.gov/gainfiles/200703/146280323.pdf.

———. 2007e. "Indonesia. Oilseeds and Products Annual Report 2007." GAIN Report ID7007, March 1. www.fas.usda.gov/gainfiles/200702/146280302.pdf.

———. 2007f. "Argentina. Grain and Feed Annual 2007. GAIN Report AR7008, March 21. www.fas.usda.gov/gainfiles/200703/146280568.pdf.

———. 2007g. "Colombia. Sugar Annual 2007." GAIN Report CO7007, April 10. www.fas.usda.gov/gainfiles/200704/146280786.pdf.

———. 2007h. "Thailand. Sugar Annual 2007." GAIN Report TH7048, April 10. www.fas.usda.gov/gainfiles/200704/146280762.pdf.

———. 2007i. "Argentina. Sugar Annual Report 2007." GAIN Report AR7009, April 10. www.fas.usda.gov/gainfiles/200704/146280767.pdf.

———. 2007j. "Australia. Sugar Annual 2007." GAIN Report AS7020, April 10. www.fas.usda.gov/gainfiles/200704/146280774.pdf.

———. 2007k. "Brazil. Sugar Annual 2007." GAIN Report BR7003, April 10. www.fas.usda.gov/gainfiles/200704/146280965.pdf.

———. 2007l. "India. Sugar Annual Report 2007." GAIN Report IN7035, April 20. www.fas.usda.gov/gainfiles/200704/146280893.pdf.

———. 2007m. "Malaysia. Biofuels: Biofuel Bill passed on April 16, 2007." GAIN Report MY7014, April 20. www.fas.usda.gov/gainfiles/200704/146280889.pdf.

———. 2007n. "France Bio-Fuels. French Biofuel Production Plans 2007." GAIN Report FR7001, May 1. www.fas.usda.gov/gainfiles/200701/146279894.pdf.

U.S. EIA (Energy Information Agency). 2005. "Renewable Fuels Legislation Impact Analysis." July. www.eia.doe.gov/oiaf/servicerpt/jeffords/pdf/s606_s650_analysis.pdf.

U.S. EPA (Environmental Protection Agency). 2002. "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, Draft Technical Report." EPA420-P02-001, October. www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf.

———. 2007. "Regulation of Fuels and Fuel Additives: Renewable Fuel Standard Program." www.epa.gov/otaq/renewablefuels/#regulations

USITC (U.S. International Trade Commission). 2007. "U.S. Import/Export Data." www.usitc.gov/.

U.S. National Alcohol Fuels Commission. 1981. *Fuel Alcohol: an Energy Alternative for the 1980s*. Washington, D.C.: U.S. National Alcohol Fuels Commission.

Valdes, Constanza. 2006. “Brazil’s Booming Agriculture Faces Obstacles.” *Amber Waves* 4(5): http://www.ers.usda.gov/AmberWaves/November06/Features/Brazil.htm.

Van der Mensbrugghe, Dominique, and John C. Beghin. 2005. “Global Agricultural Reform: What is at Stake?” In *Global Agricultural Trade and Developing Countries*, eds. Ataman Aksoy and John C. Beghin, chapter 7. Washington, DC: World Bank.

Wall Street Journal. 2006. “Crude awakening: As alternative energy heats up, environmental concerns grow.” December 5.

Wang, Michael, C. Saricks, and D. Santini. 1999. “Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions.” Center for Transportation Research, Argonne National Laboratory, January. www.transportation.anl.gov/pdfs/TA/58.pdf.

Washington State Legislature. 2006. “Engrossed substitute Senate Bill 6508.” http://www.leg.wa.gov/pub/billinfo/2005-06/Pdf/Bills/Senate%20Bills/6508-S.E.pdf.

WTO (World Trade Organization). 2007. www.wto.org/english/thewto_e/thewto_e.htm.

World Bank. 1994. “Commodity Markets and the Developing Countries.” World Bank Quarterly, March. Washington, DC: World Bank.

Xinhua Business Weekly. 2006. “No consumption tax on biodiesel.” December 5.