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Viewpoint

Towards a sustainably certifiable futures contract for biofuels

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Abstract

How are biofuels to be certified as produced in a sustainable and responsible fashion? In the global debate over this issue, one party to the proceedings seems rarely to be mentioned—namely the commodities exchanges through which a global biofuels market is being created. In this contribution, I propose a solution to the problem of sustainability certification through a biofuels futures contract equipped with 'proof of origin' documentation. The proposal does not call for any radical break with current practice, extending existing certification procedures with a requirement for the vendor to provide documentation, probably in barcoded form, of the history of the biofuel offered for sale, including plantation and biorefinery where the biofuel was produced and subsequent blendings it may have undergone. The proposal is thus compatible with the blending practices of large global traders, whose activities are the source of the difficulties of other approaches to certification. It is argued that if such a sustainable futures contract for bioethanol (in the first instance) were to be introduced, then it would likely trade at a premium and become the primary vehicle for North–South trade in biofuels.

Keywords: Biofuels; Sustainable certification; Bioethanol futures contract

1. Introduction

In May 2007, the Brazilian Mercantile and Futures Exchange (BM&FE) launched a US$-denominated anhydrous ethanol futures contract, with a full set of technical specifications and designating ethanol deliveries at the port of Santos (Sao Paulo). This is the port through which 67% of Brazilian ethanol exports are channeled. This is a bold move by BM&FE, and intended to be the first step towards creating a global trading market for ethanol. It comes in the wake of the collapse of a similar effort launched by the NY Board of Trade, in 1994, where the ethanol futures contract failed to ignite market interest. By contrast, in the first few months of trading, the BM&FE contract is building liquidity, and could well establish itself as the premier trading vehicle for ethanol in the world.

I suggest that this development has a two-fold significance. Firstly, it demonstrates that there is progress in creating a standardized commodity market for bioethanol, with all that this implies for reliability of trading and the growth of a global market. Secondly, it acts as a template for certification of biofuels, as a simple extension of the technical certification that is already required as part of the futures contract.

A global debate rages on the issue of certification of biofuels to ensure their sustainable and responsible production. While several schemes for certification have been proposed, and sets of criteria have been drawn up, including by a government-level panel in the Netherlands, nevertheless the models of certification have yet to inspire confidence or credibility. They lack 'traction' in the real world of market trading.

In this contribution, I discuss the prospects for certification of biofuels by linking the question to the development of futures trading contracts, which have the potential to provide some audited and legitimate certification that the biofuels are being produced in a sustainable fashion. The core of the paper is a discussion of a novel proposal: would it be feasible to see certification criteria incorporated in a trading instrument such as a biofuels futures contract? If this were to be achieved (and it would be the first time that such certification would be effected through trading of a commodity) then it would solve a lot of problems

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simultaneously. It would settle the issue of who is responsible for 'certifying' that the commodity has been produced in a responsible manner: the certifying would have to be provided by the party offering the commodity for sale. It would settle the issue of allocating costs of certification along the value chain; the costs would be borne ultimately by the vendor. Above all, it would be compatible with the business model of global commodities trading houses, which make their profits by blending a homogeneous commodity such as bioethanol. This fact is what vitiates almost all previous and present proposals for certification of biofuels: no matter how well-certified they might be at the production end of the chain, when blended by a trading house there is no possibility of tracing these different production origins (say, Malaysia) through to a point of distribution or consumption (such as in Europe). The certified futures trading contract solves this problem by carrying some declaration as to its 'proof of origin' in a barcoded form that will move with the traded quantity (on the BM&F, a 30,000 liter aliquot) wherever it goes.

This is a radical but eminently practical proposal. To demonstrate this, it will be set in the context of the institutional processes involved in the construction of markets for commodities, and the progress achieved so far in the case of biofuels. The paper will then discuss the situation regarding futures contracts and their trading arrangements. It will then switch to discuss certification efforts mounted so far, and the strengths and weaknesses of the various approaches. The kinds of sustainability criteria advanced so far for biofuels will be analyzed. The core of the paper consists in bringing these two matters together, to discuss the feasibility of building such criteria into a 'proof of origin' clause to be attached to commodity trading vehicles. The practical possibilities for such an arrangement will be canvassed, as well as the implications for global biofuels trading.

The proposal advanced constitutes, in effect, a means for building sustainability regulation of the emerging biofuels market into the trading process itself, simply by imposing the requirement to identify the origins and record of production of the biofuel. Such a step leaves open the contribution of external parties to impose sustainability criteria that can be linked to the origins declared. Biofuels could be identified as coming from Malaysia or from the Amazon; as such they could be evaluated for their sustainability characteristics. Such a 'proof of origin' requirement has evaded trade in coffee, sugar and in all other commodities, despite numerous calls for 'fair trade' or responsible certification, such as in the Forest Stewardship Council (FSC) approach to certifying timber, particularly from rainforests. But without engaging with the commodity instruments that are actually traded, the 'fair trade' in coffee amounts to less than 1% of global trade, while FSC-certified timber makes hardly any dent on illegally forested and traded rainforest hardwoods. The proposed sustainably certified futures biofuel contract would by contrast get at the root of the issue, which is to build certification into the traded instrument itself.

Whether NGOs would welcome such a development is an open question. The NGOs responsible for advancing 'fair trade' in coffee or FSC-certification of rainforest timbers no doubt see their interventions to place 'social criteria' in opposition to market criteria as a step forward. They may well see a step towards substantive self-regulation by the biofuels markets, through trading certified futures contracts, as posing a further step forward, in that such a step would promise substantive protection of the biofuels industry from irresponsible behavior. Other NGOs might not be so happy to see self-regulation take over from a situation where external parties are required to impose what they regard as essential social criteria.

In this contribution I first sketch the background to the emergence of the Brazilian bioethanol futures contract, and the long process through which commodities markets evolve. I then discuss the issues of sustainability and traceability certification, noting the models and precedents available. I then draw these two threads together in the proposal for a sustainably certified futures contract, and discuss the likely effect of a commodities market like the BM&FE introducing such a contract.

2. Futures contracts and the making of a commodities market

Commodities markets do not appear overnight. In fact, they are the institutional product of a sustained and lengthy evolution that spans hundreds of years, from the trading fairs of Champaign through the commodities markets of Antwerp and London where peppers and spices were traded, to the great mercantile exchanges of Chicago and New York that grew up around the new commodities of corn, wheat, beef and pork. Today, there are dozens of such exchanges, many of which are appearing anew in developing countries, where agricultural commodities like coffee, cotton or cocoa are traded, as well as minerals such as iron ore, tin and platinum, and of course the greatest commodity exchanges of all, those that trade in various kinds of petroleum contracts, now encompassing natural gas as well.

When traded through a commodities market, materials like corn or wheat cease to constitute just a physical bundle and become instead a bundle of contractual rights and obligations. Each such commodity trade—far from being just a physical entity—is a carefully prescribed set of technical specifications laid out in the contract, along with precise details of delivery instructions and contractual requirements as to payment and delivery. For these contractual issues are the essence of commodities trading; the buyer and the seller are both aware of them and know that breach of these contractual obligations provide grounds for legal action that can and will be used to enforce compliance. It is this bundle of specified rights and

obligations that indeed constitutes the 'contract' that is traded.[1]

When a new commodity appears, a market for the commodity is created through various steps. Initially bilateral trades take place, without any requirement for their terms to be made known to third parties. This is a state of affairs that precedes the appearance of formal markets, and continues to exist in parallel with such markets, possibly in perpetuity. It would be a brave government that sought to outlaw such 'freedom of contract'. But as the volume of such trades increases, so it becomes possible for an institution (an Exchange, or Board of Trade) to move into the space and offer a more formalized kind of trading where the price and contractual details are made public. This it could do in a variety of ways, but one common approach is to stage an auction, where a specified quantity is offered for sale, and bids are invited, with a winning bid being determined through a specified process.[2]

Auctions would be staged as one-off events, and then become regular, as in quarterly, or monthly or weekly and eventually daily events. Through this process, the volume of trading increases, as well as the number of market participants, thus increasing the market's liquidity, or its depth. A rule of thumb is that once the volume of trades equals the total volume produced, then the market is approaching an acceptable level of efficiency. Low liquidity markets are ones where the volume of trade is much lower than the total produced, while highly liquid markets are those where the volume of trading exceeds the volume produced (because of multiple trades, speculation and hedging). On the New York Mercantile Exchange (NYMEX) for example, the volume of trades in the standard-sized light sweet crude oil futures contract amounts to an average of 230 million barrels of oil per day, which is three times the physical quantity of oil produced.[3]

Eventually, the volume of trade reaches a point where an institution feels it is possible to offer a permanent trading environment where a specified commodity is offered for continuous trade. There is competition between exchanges in issuing such specified commodities—too soon (as in the NY BoT for its ethanol futures contract) and the commodity bundle languishes; too late, and the world's other exchanges have already attracted the cream of the world's commodity brokers, merchant banks and associated market participants and agents. This continuous trading results in a continuously verifiable price being established. This is what is made public through the 'market reports' that are a constant and insistent feature of modern capitalism.

A futures contract is a traded market instrument that obligates the seller to provide to the buyer a specified quantity of a commodity at a specified place at a specified price. It represents the highest stage of evolution of a commodities market. Once a market is able to offer futures contracts, then participants are able to hedge their operations (such as producers being able to hedge against future changes in exchange rates) and speculators are attracted by the possibility of making arbitrage profits.[4] Far from being an ugly side of capitalism, one could argue that speculators are the agents that give a market liquidity and encourage volume of trade.

2.1. The BM&FE ethanol futures contract

The latest chapter in the development of commodities markets worldwide concerns biofuels. The world's first bioethanol futures contract was offered on the BM&FE in the year 2000; this was a contract denominated in Brazilian Reals, and modeled on existing contracts for sugar, coffee, and soybeans. It was for delivery of ethanol at Paulinia, 200 km inland from Sao Paulo. It was a moderate success, reflecting as it did the primacy of Brazil in ethanol trade. It was followed in 2004 by the first US ethanol futures contract, issued by the New York Board of Trade; however, this did not attract market support, and trading was suspended in November 2004. Since then the Chicago Mercantile Exchange (CME) and the Chicago Board of Trade have issued ethanol futures contracts which have been trading at a modest level ever since. The NY Mercantile Exchange (NYMEX) also offers swaps contracts with the CBE, CBoT and BM&F contracts. Then in April 2007 the BM&FE issued its US$-denominated ethanol futures contract, for delivery at Santos, the port of Sao Paulo. This is currently the world's premier exchange instrument for ethanol.

The contract launched in April 2007 by the Brazilian Mercantile & Futures Exchange specifies anhydrous alcohol (ethanol) as the underlying commodity, with technical characteristics that match those spelt out in relevant standards laid down by the US (American Society of Testing and Materials: ASTM) or the Brazilian standards organization (ABNT/NBR).[5]

The contract specifies a trading unit of 30,000 l (cubic meters) and the price is quoted in US$ per cubic meter ('000 l). The bulk of the contract specifies payment and delivery instructions; electronic registration of delivery notices; margin requirements on positions held open; and

[1] On futures contracts and commodity trading, see general references such as Blank et al. (1991) or more recently Baer (2007).

[2] The design of such auctions, where the winning bid is determined by a variety of mechanisms, such as rising bids, or falling bids (the Dutch auction), is an emerging area of interesting analysis. Despite its long history, economics has yet to come up with a satisfactory theory of optimal efficiency of institutional forms of market exchange. On the design of markets, see for example Roth (2002).

[3] See the NYMEX description of the sweet crude oil futures contract, available at: http://www.nymex.com/QM_desc.aspx.

[4] On the theory of futures contracts and arbitrage, there is an extensive economics literature; for a classic contribution, see Hirshleifer (1988).

[5] The ASTM standards specified include D1613 for total acids; D1125 for electrical conductivity; D4052 for specific mass at a specified temperature; D5501 for ethanol content (if produced from a source other than sugarcane); and D1722 for hydrocarbon content.

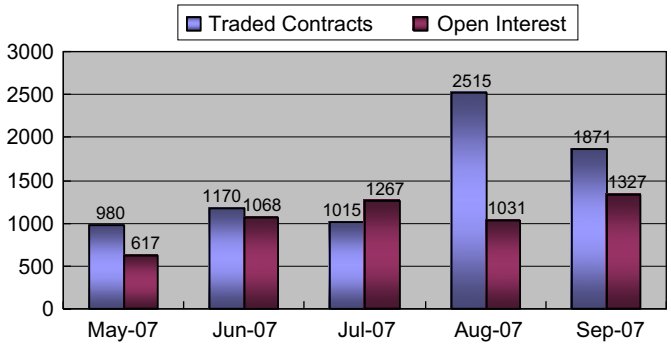

Chart 1. Number of traded bioethanol futures contracts and open interest, 2007. *Source*: BM&F: http://www.bmf.com.br/portal/pages/imprensa2/destaques/2007/outubro/Ivan.pdf.

documentation regarding the quality of the ethanol in the form of a Certificate of Analysis and Classification.[6] The seller must make such a certificate available, and the buyer can then conduct his or her own analysis, and if needed in the case of dispute, can request a deciding analysis by the BM&FE itself. In this sense, the exchange acts as institutional arbiter and enforcer of the rules of the game.

The new contract has acquired a respectable level of trading, in terms of depth and liquidity. As shown in Chart 1, the number of traded contracts rose to a peak after four months of trading, at 2515 contracts settled in the month of August, and with many of the contracts remaining open. Whereas earlier efforts by BM&FE to create futures commodities markets have met with mixed success, this particular contract looks to be firmly established.

3. Sustainability certification and traceability of biofuels

The major obstacle to the further growth and development of a global biofuels market is not so much the tariff barriers and subsidies that distort markets (bad enough as these are) but the issue of demonstrating sustainability and 'certified' contribution to greenhouse gas emission reductions.

Sets of technical specifications are starting to be produced, reflecting public concerns over such matters as deforestation associated with biodiesel production from palm oil.[7] The most comprehensive of these sets of specifications are those produced by the Cramer Commission in the Netherlands, the world's first criteria to be given the imprimatur of a government.[8] Such criteria only become of practical significance if they are incorporated into standards or specifications.

Clearly there is no future in requiring traders in biofuels to mandate their product as being 'carbon negative' (drawing more carbon from the atmosphere than is put back through burning) or 'carbon neutral' through some kind of 'field to wheel' analysis. These are scientific studies and they can shed light on the characteristics of fuels grown from certain feedstocks in certain parts of the world or on certain kinds of soils; but they cannot be enforced as such through trade. While bodies such as the RoundTable on Biodiesel established in Malaysia may give their imprimatur to biofuels produced by member firms, this may have little credibility with consumers. Yet consumers have no way of acting on such suspicions for as long as biofuels from different origins are blended by global commodities traders.

One way forward is for authorized bodies such as the UN Framework Convention on Climate Change (UNFCCC) and in particular its Executive Committee established to implement the Clean Development Mechanism under the Kyoto Protocol to play a role, such as through making decisions over how to allocate carbon credits and deciding which practices should be rewarded with credits and which should not. This is a promising approach as yet in its infancy.

An alternative (and parallel) avenue would be through commodity exchanges eventually implementing such criteria in their biofuel futures contracts—as explored in this article. But first we must establish that sustainability and traceability are indeed widely taken up in the world of agricultural and livestock commodities.

3.1. Traceability of commodities

The world's most advanced system for traceability of biological commodities is the Japanese system introduced to protect against Bovine Spongiform Encephalopathy (BSE) or Mad Cow Disease. Under the Beef Traceability Law, which took effect in December 2003, the full traceability of domestically raised beef was mandated. Every cow raised in Japan carries a 10-digit ID number allocated and tracked by the National Livestock Improvement Center. The ID covers: breed, gender, date of birth, place of birth, place of feeding, transfer records, place of

[6]The full text of the BM&FE Bioethanol futures contract may be found here: http://www.bmf.com.br/portal/pages/frame.asp?idioma=2&area=contratos&link_char=Agri42. For a presentation on the first few months' experience with the ethanol futures contract, see here: http://www.bmf.com.br/portal/pages/imprensa2/destaques/2007/outubro/Ivan.pdf.

[7]Sustainability of commodities production has been discussed in an extensive literature; see for example Clay et al. (2005) for an overview. For a general discussion of certification in the forestry industry, see Rametsteiner and Simula (2003). For the biofuel industry, Verdonk et al (2007) draw on several case studies, including a discussion of the Forest Stewardship Council (FSC) and its approach to certification of forest products. These authors propose a bioenergy labeling organization (BLO) and a United Nations Agreement on Bioenergy (UNAB) but do not consider the role that could be played by commodities exchanges. Eco-labeling for energy efficiency purposes is discussed in Banerjee and Solomon (2003), while Monteiro and Rodrigues (2006) discuss eco-certification of agriculture generally.

[8]The Commission was established by Dutch Environment Minister, Jacqueline Cramer, and released its first report in July 2006 (in Dutch): http://www.snm.nl/pdf/1000_060714biomassarapportciecramerjuli2006.pdf. For a news report on the Commission, see: http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20070428/dutch_biofuel_070428?s_name=&no_ads.

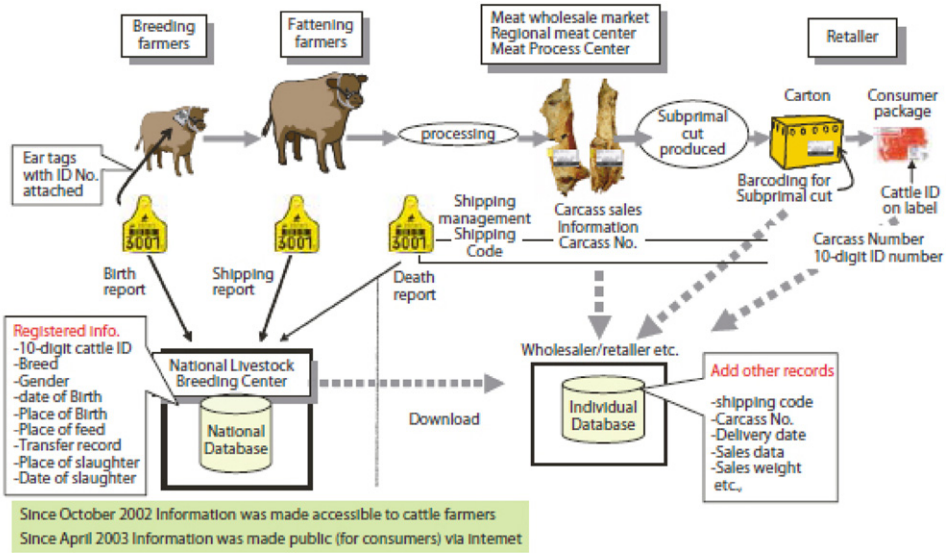

Chart 2. Japanese beef traceability system. *Source*: GS1 Japan: http://www.gs1jp.org/04/04-2.htm.

slaughter and date of slaughter. The full system is exhibited in Chart 2.

Indeed, traceability of commodities is being widely discussed as the next step in meeting consumer concerns over the safety of foodstuffs production, whether livestock (beef and BSE; poultry and Avian Flu) or crops grown from GMOs.[9] Thus, there is no fundamental objection on the part of commodities traders to the idea of traceability.

3.2. Social certification of biofuels

Another recent development is the practice of 'social certification' introduced by Brazil to ensure that biodiesel produced is contributing to the social development of rural areas. There is a distinct and explicit social goal to the biodiesel program. Learning from the experience of the pro-alcohol program, the Ministry of Agrarian Development (MDA, which is pro-small farmers) has shaped the biodiesel program with its 'seal of social responsibility' meaning that small farmers have to contribute over 50% to a large trader's or distributor's biodiesel. It is only with such a seal that large companies receive tax credits and are allowed to bid at the national biodiesel auctions. The impact has been dramatic. The President, Lula, who backs this program as the central initiative of his presidency, claims that 100,000 jobs have been created in Brazil's impoverished NorthEast through growing oilseeds (mainly castor oil). This is backed by data from the Ministry (MDA) showing that since the launch of the program, just over 200,000 small family-owned farms have been induced into growing oilseeds.[10] Thus, there is no fundamental objection on the part of commodities traders to the idea of certification as an additional requirement built into trading contracts.

4. The proposed sustainably certifiable biofuels futures contract

A certified biofuels futures contract brings together the ideas of traceability and certification and embeds them in the contractual details governing the trade in the commodity. My proposal is that the existing Certification of Analysis and Classification that forms part of the existing Bioethanol futures contract offered by the BM&FE be extended to provide proof of origin of the feedstock and the ethanol, in addition to the technical specifications currently required. Thus, a new 'sustainable' ethanol futures contract would call for provision by the seller of a Certificate of Analysis, Classification and *Proof of Origin*, where the proof of origin would supply data concerning the plantation where the feedstock was grown and the biorefinery where the fuel was produced, and subsequent blendings of the fuel, carried in barcoded form. If the commodity is blended with ethanol from other sources, and onsold through another exchange (e.g. in Europe) then the blended ethanol would likewise carry a barcoded proof of origin, reflecting the sources of the blended product, and the exchanges through which it has passed. A multiply blended and multiply onsold commodity would have to carry the entire history of its blending and sales in its barcoded proof of origin. In this way, the proposal demonstrates its compatibility with the blending practices of global commodity traders such as ADM, Cargill or Bunge. It is the incompatibility of existing certification schemes with these blending practices that has constituted an insuperable barrier to practical certification of sustainability so far.

[9]On traceability of biological products generally, see the reviews by Opara (2002) or Loftus (2005).

[10]On the social certification of the Brazilian biodiesel program, see the discussion in Sparovek et al. (2007) and in Mathews (2007a, b).

The existing precedents for imposing traceability and social certification procedures on the trading of commodities in general and biofuels in particular demonstrate that there are no technical obstacles standing in the way of such a development. The simplicity of the scheme lies in its building the certification into the body of the contract, in such a way that certifying comes to be seen as part of the process of validating the quality and standards of a commodity offered for sale. The proposal places the responsibility for providing such certification firmly where it belongs, namely on the vendor offering the biofuel for sale. The proposal places the responsibility for auditing and validating the certification also where it belongs, namely on the commodities exchange that hosts the trade in such certified futures contracts.

5. The workings of a global biofuels market with sustainability certification

How then would a global biofuels market work where there is the option for trading biofuels contracts equipped with 'proof of origin' documentation? Proof of origin certification ensures that the source of the biofuel be made known, and that through this its compatibility with locally certified sustainability criteria may be tested.

Initially, the mere presence of proof of origin certification could be expected to ensure that the new contract would trade at a premium to any existing contract that offers no such proof of origin. This is because information regarding origin is better than having no such knowledge. As the contract builds liquidity and the number of trades increases, so the exchange hosting the contract would be able to publish data as to the actual origins of ethanol traded on the exchange over several months. Buyers would be able to match this data against what is known concerning these points of origin. Most of the plantations and biorefineries involved would no doubt seek independent certification as to their compliance with standards, such as their audited use of cogeneration as a means of reducing fossil fuel inputs into the biorefining process, and thus their being a source for the 'sustainable' futures contract would enhance its premium value.

Eventually biofuels of different origin might trade for different amounts, with bioethanol from Brazil, for example, attracting a premium over bioethanol produced from corn in the US or from sugar beet in Europe. This has already happened in the case of petroleum trading (e.g. Brent crude from the North Sea) and there is no reason why it might not be expected to happen with biofuels as well.

The key to success of any such certifiable futures contract would rest with its tradeability—with the depth and liquidity of the trading on commodities exchanges that offer the contract. Here Brazil's latecomer institutions might be able to play a role if indeed the BM&FE were to be the first to take the step towards certifiably sustainable futures contracts. The national oil company (and already the national biofuels company) Petrobras could play a role in helping to 'make the market' through deliberate trading on the BM&FE—just as Petrobras has helped to create a biodiesel market in Brazil through being buyer of last resort on auctions staged by the National Fuel Agency (ANP). In this way, Brazil's institutions are cooperating to create a sustainable domestic market for biofuels that will serve as platform for a global market.

6. Concluding comments

The potential size of the global market for biofuels traded through commodities exchanges is enormous. Within a decade it could come to rival the size of the market for petroleum—and it will be growing, while the market for petroleum will be contracting. The commodities markets have not been recognized as having a role to play in the quest for sustainability of biofuels—to date. While their role in expanding the extent of the market for biofuels is recognized, the further role that they could play in enforcing standards is not so widely understood. In this paper, I have sought to demonstrate that futures contracts for biofuels equipped with sustainability certification have the potential not only to grow a global market but to do so in a sustainable fashion. I have sought to demonstrate that a 'proof of origin' clause is all that is needed to have a large impact. This is a simple and powerful expedient, and one that is entirely compatible with existing blending activities by large traders. It raises the question: which will be the first of the world's commodity exchanges to offer such a sustainably certifiable bioethanol futures contract?

References

Baer, J.B., 2007. Commodities Exchanges and Futures Trading: Principles and Operating Methods. Baer Press, Lake Forest Park, WA.

Banerjee, A., Solomon, B.D., 2003. Eco-labeling for energy efficiency and sustainability: a meta-evaluation of US programs. Energy Policy 31 (2), 109–123.

Blank, S.C., Carter, C.A., Schmiesing, B.H., 1991. Futures and Options Markets: Trading in Commodities and Financials. Prentice-Hall, Englewood Cliffs, NJ.

Clay, J.W., Dufey, A., MacGregor, J., 2005. Leverage points for encouraging sustainable commodities. Paper for conference 'Strategic Dialogue on Commodities, Trade, Poverty and Sustainable Development', Barcelona, Spain, 13–15 June 2005.

Hirshleifer, D., 1988. Risk, futures pricing, and the organization of production in commodity markets. Journal of Political Economy 96 (6), 1206–1220.

Loftus, R., 2005. Traceability of biotech-derived animals: application of DNA technology. Review of Scientific Technology Office International des Epizooties 24 (1), 231–242.

Mathews, J.A., 2007a. Can renewable energies be turned to a source of advantage by developing countries? Revue de l'Energie 576, 96–105.

Mathews, J.A., 2007b. Biofuels—what a biopact between north and south could achieve. Energy Policy 35, 3550–3570.

Monteiro, R.C., Rodrigues, G.S., 2006. A system of integrated indicators for socio-environmental assessment and eco-certification in agriculture. Journal of Technology Management and Innovation 1 (3), 47–59.

Opara, L.U., 2002. Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future

prospects. Journal of Food, Agriculture & Environment 1 (1), 101–106.

Rametsteiner, E., Simula, M., 2003. Journal of Environmental Management 67 (1), 87–98.

Roth, A.E., 2002. The economist as engineer: game theory, experimentation, and computation as tools for design economics. Econometrica 70 (4), 1341–1378.

Sparovek, G., Berndes, G., Egeskog, A., Mazzaro de Freitas, F.L., Gustafsson, S., Hansson, J., 2007. Sugarcane ethanol production in Brazil: an expansion model sensitive to socioeconomic and environmental concerns. Biofuels, Bioproducts and Biorefining, published online Wiley InterScience, doi:10.1002/bbb.31.

Verdonk, M., Dieperink, C., Faaij, A.P.C., 2007. Governance of the emerging bioenergy markets. Energy Policy 35, 3909–3924.