Certification Strategies, Industrial Development and a Global Market for Biofuels[1]

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Belfer Center Discussion Paper 2009-15
October, 2009

1 This document was prepared for the Conference on Biofuel Certification at Harvard University, May 2009.

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CITATION

This paper may be cited as: Hausmann, Ricardo and Rodrigo Wagner, "Certification Strategies, Industrial Development and a Global Market for Biofuels," Discussion Paper 2009-15, Cambridge, Mass.: Belfer Center for Science and International Affairs, October 2009.

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ACKNOWLEDGEMENTS

The authors would like to thank seminar participants at San Servolo (2008), as well as participants in the Conference at Harvard (May 2009) for helpful discussions and comments to previous versions of this paper. Laura Ardila, Jitka Thomas and Giovanni Zambotti provided very helpful research assistance. Anne Morriss made valuable edits to various drafts of this paper. The authors acknowledge the financial support of the Italian Ministry of the Environment, Land and Sea for this research.

ABSTRACT

A disproportionately large amount of the world's agronomic potential for the production of bio-ethanol is concentrated in a subset of developing countries. To develop that potential, countries need both the existence of an appropriate local business ecosystem and reliable global demand. The creation of a global market for green biofuels, however, is affected by a constellation of diverse and sometimes conflicting policy goals, which tend to complicate policy discussion. In this paper we compile a set of principles to guide the design of a global market for green biofuels

Key words: market design, bio-energy, ethanol, sugarcane.

JEL Classification: Q48 – L52 – F14 – F18.

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> "*There will be green (trade) barriers. So developing countries which want to sell their produce [*to the developed world*] need to demonstrate they have taken measures to avoid that their production increases pollution*".
> Ricardo Lagos. UN Special Envoy on Climate Change (June, 2008).

1. Introduction

A disproportionately large amount of the world's agronomic potential for the production of bio-ethanol is concentrated in a subset of developing countries. This phenomenon represents a rare opportunity to help countries that rank among the poorest in the world to make progress towards industrialization and export-led growth. The list of potential biofuel[3] competitors includes small, tropical economies where the current denominator of total exports is low, so the development of even a small biofuel industry could represent a large proportion of exports. By creating demand for relatively complex inputs and capabilities, the industry's development may also make it easier for these countries to develop other more sophisticated industries in its wake. The emergence of a biofuels industry, therefore, may not only be meaningful for global energy supply, but may also promote the competitiveness of some of the world's most vulnerable communities.

This opportunity is being threatened, however, by the complexity of the coordination challenges, like standardization and the building of an integrated supply chain, as well as by the large number of policy priorities that are shaping the industry's emerging structure. This paper will discusses all these tensions in the context of the international policy debate.

Creating a viable global biofuels market depends on a range of both local and global policy inputs. Translating the biological potential for biofuels into an economically exploitable opportunity requires a business ecosystem that provides the intermediate inputs and market structures that maintain the private cost of production below the sale price. Since this complex network of requisite conditions – infrastructure to connect agricultural land with ethanol processing plants, a logistic system to move the ethanol to port or to market, ports that can handle ethanol, a car fleet that can use the ethanol, refineries that mix ethanol with gasoline in known ratios, a network of service stations that sell the mix, etc. – can neither be developed quickly nor provided by a single firm, it is crucial to coordinate entrant entrepreneurs by providing

[3] There are two first generation biofuels: ethanol and biodiesel. Roughly speaking, the biodiesel is of higher quality than ethanol. The downside is that it resists mechanization and thus is expensive. Although some features of the discussion in this paper may apply to biodiesel, our central concern in this paper, as note in the first paragraph, will be the bio ethanol.

certainties.

At the local level, these industry dynamics imply an organization of buyers and some basic complementary inputs. Some of these inputs are privately provided, but many others are in the purview of the public sector, such as infrastructure or standards. Ensuring that these are provided simultaneously represents a coordination problem that requires policy action.

At the global level, given the large scale of potential production relative to the size of domestic markets and given potential hold-up problems between producers and local distributors, reliable global market demand is needed in order to trigger large bioenergy investments. Global certainty is particularly important for biofuel entrepreneurs. The only fully scalable carbon-saving production technology available that is profitable at around US$ 60 per barrel[4] - sugarcane ethanol - requires comparatively large investments in local processing compared to other well developed agricultural-based industries like wheat or soybeans, increasing the salience of potential market failures in its development. A global market is critical to ensuring demand and to giving producers an outside option.

But it is not yet clear how this market will function. The market's structure is being shaped haphazardly by a series of different and sometimes conflicting policy goals. For example, biofuels have been affected by agricultural policies in developed countries focused on increasing local farm incomes by restricting supply and raising domestic prices. One implementation of this policy is the American US$ 0.54 per-gallon tariff on imported ethanol, which makes imports unfeasible at all but the very high oil prices seen briefly in 2008.[5] The opposite policy goal – that of keeping food prices low – has also been a consideration regarding biofuels policy, as many fear that increased competition for arable land would raise food prices and deteriorate the living standards of the urban poor. One implementation of this policy is to stop the promotion of biofuels, as suggested by some specialists in the press, especially during the food price spikes of 2007-2008.

At the same time, biofuels are seen as a potential substitute for imported fossil fuels and are being encouraged in some developed countries for energy security reasons, since they would reduce dependence on failed or potentially hostile oil-rich states. Through this lens, Brazilian sugarcane farmers would be competing with Iranian and Russian oil magnates, not Iowa corn

[4] Although the relevant comparison is gasoline and not crude oil, we use benchmark values in terms of oil barrels because it is standard in many discussions of energy economics.
[5] As we will discuss in the next sections, this is because the goal is to benefit only local producers.

farmers.

Environmental goals are also a primary factor in the industry's emergence, but leveraging biofuels to advance these goals is not clear-cut. First, some biofuels have the potential to lower greenhouse gas (GHG) emissions, because the carbon their combustion releases is offset by their capture of CO_2 through photosynthesis. But not all biofuels are created equal. Some have large reduction effects, while others have small or adverse effects. Moreover, CO_2 is not the only GHG, and agriculture may generate others such as methane and nitrous oxide. A policy to reduce GHG emissions would need to distinguish between them, but this cannot be done by just looking at the chemical composition of the final product. Hence, some form of certification would be needed. Second, GHG emissions are not the only environmental goal. Agriculture disturbs the environment through deforestation, chemical pollution of land and water and a reduction in biodiversity, among other ways. Hence, a policy to encourage biofuels would expand the agricultural frontier and thus affect the environment.

This paper engages this discussion with two central goals: first, to compile a set of principles to guide the design of a global biofuels market that reconciles industrial development with the other policy goals around the industry and, second, to offer practical implications that ground these principles in the landscape of the current policy discussion.

We seek to contribute to this discussion in a variety of dimensions. First, unlike other normative pieces, we emphasize the industrial development potential of bioenergy and the implications of incorporating this goal into emerging policies at both the local and global level. In particular, we argue why it is so important to avoid regulations that are highly intensive in State capacity which, among other things, would bias industrial development against poor countries. Second, we explore the trade-offs of multiple policy goals, ending with a call for either adding more instruments or reducing the goals. If you will indulge an unfortunate metaphor for an environmental issue, a single certification stone is unlikely to kill all of the birds we are targeting. Third, we propose *scaffolding regulations* to deal with an uncertain global institutional environment for bio-energy. Just as the rules that started the Chicago Board of Trade in the mid XIX century are not the same ones that govern the global commodity business today, so the rules for green bio-energy must be allowed to co-evolve as the market develops. Last, we argue that the global regulation of bio-energy must be compatible with a global trading system and be mindful of transaction costs. We have to make a global market for bio-energy as green as possible, but not

go beyond that.

The rest of the paper is structured as follows. Section 2 starts by showing the potential for bioenergy, particularly in some developing countries. Immediately after, we argue why it is disproportionately important to avoid holdups for entrepreneurs in the industrial development of bio-energy. Section 3 discusses why doing so is challenging, because different and conflicting policy goals pervade the policy arena of biofuel. Subsequently section 4 develops a framework of organizing principles to deal with these conflicting goals. In section 5 we offer some examples and applications of these organizing principles. Finally, in section 6 we offer some conclusions and suggest some proposals for regulation.

2. Biofuels: an opportunity for Industrial Development near the tropics

Biological energy can be an important export product for developing countries. In this section we estimate the economic relevance for developing countries *if* their bioethanol potential is developed. Furthermore, we explore which bottlenecks may be keeping these regions from developing their bio-energy potential.

2.1 How big could biofuels be for developing countries?

Predictions about the global bio-energy production potential are not in short supply. For example, Berndes *et al* (2003) review 17 articles and find huge variances across the estimates[6], arguing that the key uncertainties comes from *land availability* and *yields*. Since then, many other papers have attempted to measure the size of the bioenergy export industry *if fully developed*. These studies, however, do not focus on the potential *development impact* of such an industry for developing countries.

To get a ballpark estimate of the industry's potential size in different countries, we create simulations based on the use of available GIS data: FAO data on irrigation and land cover, as well as FAO-IISA estimates of crop suitability (e.g. Fischer at al, 2007; Fischer at al, 2009). In particular, we focus on sugarcane ethanol as it is the only scalable technology available right now.

Assuming a price of 60$/BBL of oil, which pins down the price of ethanol, we simulate the size of the industry as a percentage of current total exports. This is not because all ethanol will be exported, but as a proxy denominator of the current ability of the country to produce competitive goods. The quantity of ethanol produced is calculated as the potential yield per pixel[7] (as defined by the FAO-IISA study), but is restricted to suitable areas located less than 1000 km away from the sea, which is our way of creating a proxy for problematic transportation of landlocked areas. Notably, we make an extreme assumption regarding land use *changes:* the new area calculated is *in excess* of current crop production areas in each country and also excludes as potential agricultural area any National Parks or official Natural Protection Areas. Pastures that are not considered crop land may be overstating the figures for some countries such as Argentina. This is not a major impediment to our goal of understanding the order of magnitude of this

6 Some of them are use a pure agronomic lens to answer how big can the bio-energy be, while others use sophisticated computable general equilibrium analysis

7 Each pixel has a different size depending on the distance from the equator.

potential industry, since the countries with large pasture-lands tend to be richer. Finally, we did *not* restrict areas currently covered by forest that are not protected.

Our calculations, shown diagrammatically in Figure 2, indicate that for some countries in central Africa and Latin America ethanol can represent a large industry, at least relative to current exports[8]

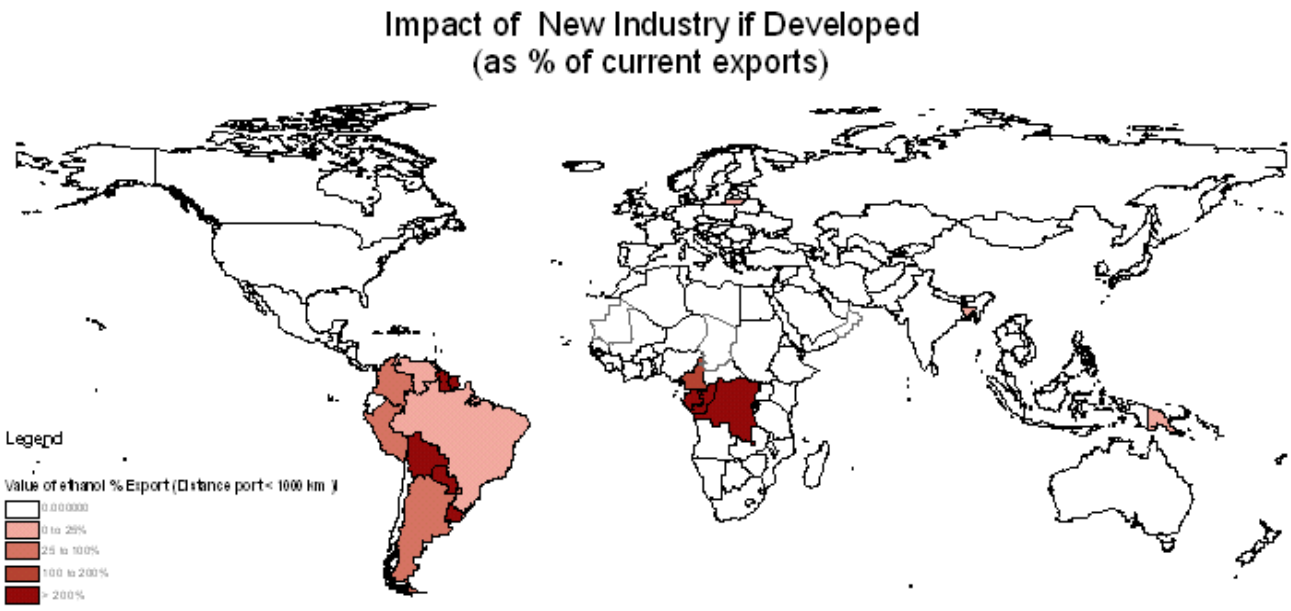

Figure 2. Results of our simulation for the impact of a sugarcane ethanol industry in terms of exports for different countries. The thought experiment uses the land not used for crop production but suitable for cane. The calculations set aside protected areas but not non-protected forests.

While in absolute terms we expect the industry to be very large in Brazil, Argentina and Colombia; this list of the relative importance of biofuels is headed by Suriname, Guyana, Bolivia, Paraguay, DR of Congo, and Cameroon. These are places where the current denominator of total exports is low, so this additional industry may represent a very large proportion of exports, under the simple scenario that the resources for ethanol production have a much higher productivity in this industry than in alternative uses.

Rather than emphasizing the accuracy of these estimates, our goal is to understand the potential scale of a strategy based on replicating the Brazilian production system in other countries with similar environmental conditions. As described by other authors (Fischer et al,

8 Details of the simulation:

2007;) we find that the only cost-competitive and scalable technology currently available, sugarcane ethanol, has a bias towards agro-ecological conditions of poor tropical countries. For us, this is the starting point for the discussion. Developing the potential of biofuels as a new export industry could connect developing country workers and their communities with the global economy.

2.2. Why production is not taking place in areas with agronomic potential?

Today, however, with the exception of Brazil, the regions referenced do not produce relevant quantities of ethanol. We argue here that this represents large unexploited potential.

The standard question an economist would ask here is why, if the potential is so promising, few entrepreneurs have discovered this great opportunity. Our argument is that there are non-agronomic constraints to economic activity, and given the technological attributes of current ethanol production, these constraints may be more binding than for other industries. Notably, these constraints are very hard to remove for each individual entrepreneur, so not producing becomes the equilibrium outcome. Among these constraints are governance problems that create a poor environment for sunk specific investments (like an ethanol plant or a sugar cane plantation). If expectations of expropriation are high, investors never show up because they anticipate future losses. Another constraint is the lack of a reliable and predictable demand, which is precisely where a global market enters, providing an outside option to producers who may otherwise be trapped in a small domestic market.

Public inputs are particularly important to the development of sugarcane. Figure 3 shows the expansion of land under cultivation by type of crop in Brazil. It shows that the area covered by sugarcane grew much more slowly than the area devoted to soybean. This is the outcome of the fact that sugarcane requires much more infrastructure for its development. While soybeans can be put on a barge at a small private port along the many navigable rivers in the Paraná and Paraguay river basins and processed far away, sugarcane must be trucked to a nearby processing plant, normally less than 50 km (Figure 4) away. This creates the need for commitments, to avoid one party holding up the other.[9] Similarly, after processing the transportation of ethanol needs specificity. While soybeans come “self” packed and processed, ready to travel anywhere, ethanol

9 For an interesting discussion of the situation in Cuba circa 1900 on the holdup issue see Alan Dye's paper (1994) “Avoiding Holdup: Asset Specificity and Technical Change in the Cuban Sugar Industry, 1899-1929. Journal of Economic History, Vol. 54, No. 3 (Sep., 1994), pp. 628-653

needs to be transported in specialized containers or pipeline. But of course investors do not build pipelines when it is not obvious that there is enough supply on the one hand and enough demand on the other.

As such, the explanation for the comparatively explosive growth of soybeans is not only biological. Indeed, according to FAO-IISA (2007) there are only minor differences in the agronomic suitability for sugarcane and soybeans on the borders of the Amazon River. But access to fast and cheap transportation by sea puts this area much closer to global markets than, for example, Sao Paulo's main cane areas, located more than 500-1,000 km from the port. Thus, the location of economic activity is endogenous to incentives: in the absence of global markets, producers may inefficiently produce *too* close to the cities that concentrate demand[10]. This location is also biased by the fact that institutions facilitating economic contracts, such as law and order, tend to work better in the proximity of successful cities in developing countries (see Cunha da Costa, 2004).

Recreating Brazil-type ethanol industries in other countries is likely to require many public inputs, as it did in Brazil.[11] However, we do not expect governments to solve their governance problems overnight, which suggest an important role for the global market as a coordinator. The development of a global biofuels market can act as a type of insurance against expropriation through price manipulation, provided that trade remains free. Once expropriation and demand are resolved, fixing the provision of the remaining public and private inputs becomes more attractive as it would trigger a stronger supply response. Infrastructure, good governance and responsiveness to entrepreneurial needs may be solved locally, for example, in an industrial zone for bioenergy production. This is important because many countries cannot provide good infrastructure and property rights enforcement throughout the entire economy, but may be able to do so in designated places.

[10] Being located close to demand is not an inefficiency per se, because there are certainly transportation costs involved. The point is that without a global market areas that would be competitive for production are not producing because they do not have local demand.

11 In remote areas of Brazil and Paraguay soybean cultivation has exploded, especially in areas that have are close to a river (e.g. Paraguay River, Amazons...). With a basic transitory port is it possible to ship soybean production many miles away.

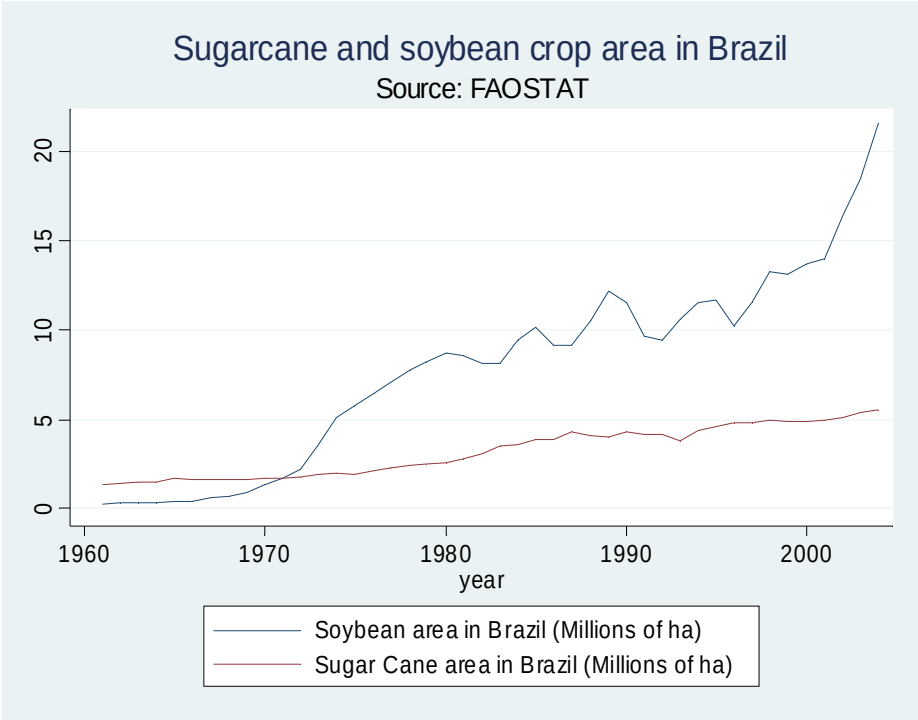

Figure 4. Evolution of sugarcane and soybean area in Brazil. Source; FAOSTAT (2008). Unlike the explosive growth of soybeans, sugarcane has been growing at smaller rates.

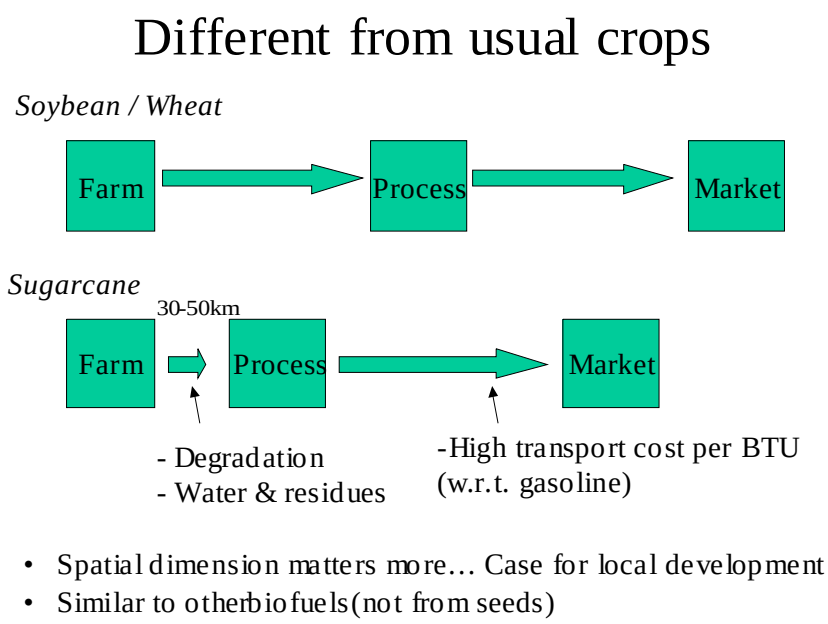

Figure 5. Diagram comparing soybean and sugarcane cultivation in terms of the need for a close processing facility.

In short, specificity and complementarity are more important for sugarcane than for other

crops. This makes sugarcane development more challenging. Nonetheless, this also makes it more attractive as a stepping stone for further development of *other* industries with more complexity that what we have in the tropics today. Bio-ethanol regulation that succeeds in promoting both development goals and environmental sustainability must be informed by these characteristics.

2.3 Overcoming Constraints to Biofuel Entrepreneurship: the business ecosystem

Coordination failures for new producers must be overcome in order to fully develop a biofuels industry in developing countries. Here we discuss these coordination problems – along with the larger value of solving them -- and argue that a global market can be one element of the strategy for developing this industry.

Many developing countries do not have industries that are able to connect their labor force with global demand. Each product requires specific knowledge, capabilities and other factors, and it is often unprofitable to invest in their accumulation unless there is reasonable certainty that these efforts will be rewarded. Given the many independently-provided inputs that must be present for production to occur, individual entrepreneurs have difficulty managing the requisite coordination, and production does not take place because costs would be higher than the private benefits. If one input, like a pipeline, is not matched with complementary inputs, like processing facilities, there is no possible business; and viceversa

Firms can overcome these dynamics, however, through high rates of learning and access to appropriate inputs. As argued in stories of dynamic comparative advantage, countries need time to develop a particular production process. This challenge describes many of the issues that can plague a newborn bioenergy industry. A first issue is “learning by doing,” which is the dynamic reduction in unit costs due to the experience gained from previous production. This learning curve is not necessarily a market failure if it happens *within* the firm. If proper financial engineering exists, a firm can produce extra units today, because that can reduce tomorrow's cost of production. In this case, the requisite inputs are deep pockets and forward-looking entrepreneurs. In most cases, however, the firm cannot capture all the benefits because learning must also occur outside the firm, whether within the industry or along its value chain. For example, effective regulation, reliable suppliers of intermediate goods, the formation of specific human capital or the actual R&D developed usually happen outside a single firm. In these cases, the gap between social and private incentives creates a trap for the first entrepreneur to enter the

market. As described in Hausmann and Rodrik (2003), the first entrant pays very high costs for starting an industry from scratch, but cannot privately appropriate some of the benefits.

The availability of inputs required by new products depends on whether these inputs are readily available, for example because they are already being demanded by existing industries. Hence, the existence of other activities with similar input needs facilitates the move to products that can use those inputs. So each activity, by spawning the development of its requisite inputs, provides inter-industry spillovers to new activities that can use those inputs. In poor countries, where few activities exist, moving into new products is disproportionately more challenging – and more valuable -- because of the narrow set of existing inputs and capabilities (see Hausmann and Klinger, 2007; Hausmann and Hidalgo, 2009).

The development of a biofuel industry, by creating demand for inputs and capabilities such as transport infrastructure, manufacturing capacity, logistic systems, engineers and market experts, may make it easier for other industries to develop in its wake. In this sense, the industry could act as a stepping stone to other potentially more sophisticated industries that would not emerge in isolation.

For example, an extension of a transportation network can be financially justified by energy production in the area. But once this infrastructure is available, other projects may become feasible. In a similar way, agglomeration externalities can emerge around processing centers. There may be some demand for specialized human capital (to repair the processing plant, to control the biochemical process), a specialized provider of machinery, or even a different type of entrepreneur. Anecdotally, sugar-mills were the training field for three out of the five most important *chaebols* in Korea. [12]

It is far from trivial to know ex-ante if the development of a new industry would really have these spillover effects. A pragmatic experimentation approach may be a viable way to learn whether this agronomic potential can be realized as an economic profit.

12 We do not claim this is causal, since sugar mills were one of the few activities available for Koran entrepreneurs during the Japanese occupation. However, the story also fits with the formation of an entrepreneurial class that learned how to get from the government the industry specific public goods it needed.

3. Different and conflicting goals pervade the global biofuel policy arena

An emphasis on the industrialization value of biofuels is competing with a series of different and sometimes conflicting policy concerns. Accounting for the primary policy goals related to the industry is a crucial step in the unpleasant task of organizing and prioritizing them. Thus, here we explore some of the main policy arenas now shaping the discussion.

3.1 Industrial development

Technologies that can help developing countries to make *some* progress towards industrialization are rare, and biofuel development seems to be one of them. We are agnostic regarding the ultimate competitiveness of an industry in the tropical countries listed in the previous section, but we do endorse the goal of creating an *ex ante* level playing field in developing countries in order to give them the opportunity to try to achieve competitiveness. With this frame, a reasonable policy goal would seek to avoid global regulations that bias against production in areas with limited institutional capacity. Using a more proactive development strategy, this policy agenda would even call for some kind of affirmative action to develop this industry in poor countries.[13]

3.2 Environmental policy

Controlling global warming may be the original objective for biofuels, but it is not the only one. Indeed, there is a long list of other environmental goals linked to the industry, which we will name biodiversity as a shortcut. Greenhouse gas emissions have two characteristics that make them conducive to a global market. First, they can be reasonably measured and, second, a ton of Carbon equivalent in Arizona is close to a perfect substitute for a ton in, say, Zambia. Once in the atmosphere the marginal effect in global temperature does not depend too much on where or how it was emitted.

For biodiversity, however, things are more complex. There is little clarity regarding its measurement, and current solutions focus on identifying "special" ecosystems and prohibiting production in these areas. Moreover, biodiversity in one place is far from a perfect substitute for biodiversity in another. For example, it is very hard to trade the last hectare of a particular *bioma* off against other things. While possible in principle, it seems highly impractical to agree on a set

13 Naturally, this latter possibility may be against environmental concerns for forest preservation and agricultural policy concerns about redistribution towards farmers in rich countries

of relative prices to trade off hectares of these ecosystems. In short, markets designers should not be so eager to try to replicate the success of carbon with other environmental services. But environmental impact is not only dependent on the feedstock, as the Life Cycle Analysis makes clear. What matters is the overall impact of the whole value chain, from raw materials to production to final utilization. Interestingly, current regulations in the UK and the United States are starting to deal with this situation though the use of calibrated models like GREET that measure the weighted average Carbon load of each production process or input process.

3.3 Agricultural policies

Agricultural policies in Europe and the United States aim to redistribute resources towards domestic rural areas with disproportionate political representation vis-à-vis their population. One traditional means for that goal has been to increase prices. However, to avoid redistribution leakages to *other* countries, the price subsidy is combined with some type of exclusion to foreign producers. In this context, biofuels emerged as an interesting alternative to reduce the total burden of this redistribution, as well as to bring together the political constituencies of car drivers and farmers in industrial countries. Through this frame, biofuels produced domestically are a substitute for set-aside programs or any other agricultural price subsidy in rich countries.

3.4 Food security

Making basic staples reliably affordable for poor people is among the most important goals for our society. In practice, this means making the food cheap or making poor people rich enough so that they can afford it.[14] Similarly, countries need to make sure that they can maintain sufficient food supply in the case of a bad shock, either nationally or internationally. This is not an immediate call for autarky nor food self-sufficiency, because specializing in biofuels is no different from specializing in forestry, potatoes or microwave ovens. The difference is that *when food markets do not work* well, domestic food production has an insurance value, because it is available in situations where global markets collapse. This might be relevant in places like central

14 After the 2007/08 spike of commodities it is clear is that the transition towards a global market puts pressure not only on global food supply, but also on existing stocks of grains. With high oil prices, there was a strong arbitrage in the corn market, which in the US is a substitute for fuel production. Note, however, that had there been a global market with a mandate to consume "low carbon biofuel", the mentioned arbitrage of corn prices with oil would be expected to be weaker and smoother, since corn is a much less carbon efficient feedstock than sugarcane.

Africa, for example, where poor transportation does not allow people to get grains during a drought.[15]

More importantly, food is not like any other good, since its scarcity can even turn down the institutional environment over which local markets work. This is why a reliable global food market is a complement to creating a biofuel market, so that countries with a *potential* comparative advantage in biofuel production can specialize rather than worry about costly insurance. In short, improving food markets is a goal in and of itself. But it is not clear that the burden of their improvement should be loaded exclusively on the shoulders of biofuel development[16]. As a comparison, beef consumption implies roughly seven times its weight in grains, thereby increasing the global demand for food and raising its price. Using this same logic, barbeques deserve a similar regulatory load because of their effect on food security.

3.5 Energy security: Macroeconomics and Defense

There is an increasing recognition across countries that the *option value* of a diversified energy matrix can affect cost efficiency (Bastian-Pinto et al, 2009). But countries are also revealing some bias towards domestic energy production as a means of protecting the Balance of Payments, which may be very relevant in episodes of high oil price volatility. For example, Weidenmier et al (2008) show how internal energy production protected Brazil's macroeconomic conditions during the oil price spike in 2007-2008. In some sense, this view bounds the free trade policy goals advocated by different nations. A second edge of energy policy is that some oil-producing countries are *perceived* to be unfriendly to Europe and the United States. If this view is correct, a big if, then a reduction in oil profits for producing countries can generate cost savings by reducing investments in national defense for NATO members. From this national security perspective, bionergy substitutes for oil sources that are feared to indirectly finance anti American interests.

Here we presented five policy areas that are informing the design of a global market for

15 During a drought one may grow neither biofuels nor food in a place. However, growing food in areas close to the drought can improve the odds that people get cheaper food in those countries where food is hardly tradable because of large transportation costs and poor logistics.

16 Note that the common wisdom that Africa is in bad shape because of the agricultural subsidies in USA and EU cannot be the whole story. High food prices could also have had disastrous consequences for millions of people - especially the urban poor, with an increasing gap between their income and their minimum food expenditures. This is something that deserves more study.

biofuels and loading the discussion with a disproportionately high number of policy goals. Whatever solution society ends up crafting, we argue that the right framework to think about these conflicting goals is one of tradeoffs rather than rights, particularly since snowballing rights rarely overlap into a feasible set of solutions.

4. Organizing principles for maximizing the development impact of a global biofuels market

In this section we attempt to parsimoniously organize the discussion of the previous tradeoffs though five principles. We understand we are sacrificing part of the richness of the policies discussed in the previous chapter, in return for the tractability gains of a distilled list of principles for market design.

Organizing principle 1: Provide certainty for production in places that do not have it, but do it in a way that promotes competitiveness

There is a commitment value of having an outside market for your product. Loosely speaking, this commitment becomes "insurance" against local market price fluctuations, which is naturally higher in smaller countries. This outside option also offers a protection against regulatory expropriation and the saturation of the domestic demand for biofuels. In countries with high regulatory uncertainty or local demand volatility, ex post potentially good projects may inefficiently fail because of ex ante uncertainty.

An international market increases the bargaining power of biofuel producers. They may not only benefit from the outside price, but it may also increase their bargaining power in any within-country deal[17]. The increase may trigger entry in places that at the margin would have too much uncertainty to sustain production. This is related to the commitment motive for a government to sign a free trade agreement. Following Rodriguez-Clare and Maggi (2007), a local entrepreneur might be more willing to invest knowing that the government is tying its hands to future expropriations, through enhancing the cost of doing so by promising stable and predictable trade rules. Notably, this is not something that happens with unilateral openness to trade.

A skeptic may note that Brazil did not need a global market to develop the best ethanol industry in the world. But Brazil is one of the largest countries in the world with a very large

17 As in Nash (1950).

domestic market. Moreover, the historical origins of the industry include a close relationship between industry and government, thus piggybacking on an existing business ecosystem. The sugar lobby has been powerful for centuries in Brazil, especially in the state of Sao Paulo. Sugar was a pre-existing industry with very similar requirements -- including such public goods as protection from expropriation -- that could be relied upon to create the bioethanol industry. Unsurprisingly, the Proalcool program tied to this strong special interest constituency (Martines-Filho 2006) reduced the fear of expropriation, and created close to the right incentives to invest.

It is worthwhile to remember that the failures of industrial policies in Latin America, for example, had to do with the existence of guarantees without a disciplining device for ex post unprofitable businesses. We believe that a global market can be both the carrot to convince producers to enter, but also the stick of some market test that will drop away inefficient producers.

Finally, this organizing principle implies that we should limit the intensity of any regulatory regime on the capacity of the national state. Since poor countries have weak states, adopting regulations that are very demanding of state capacity would *bias the industry against poor countries with poor state capacity*. In a world where poor countries with bioenergy potential have limited state capacity, one should avoid making it harder for them to produce. As we will discuss in the next chapter, this has to do with putting as few requirements as possible on national government. Holding everything else equal, this makes us prefer firm-level regulation because it is something that the entrant entrepreneur is more likely to be able to solve.

Organizing principle 2: Not all biofuels are created equal, so we have to tell them apart (up to a point)[18]

A global market can "promote uniformity in the customs and usage or merchants,"[19] meaning that the creation of a commodity allows *homogeneous* goods to be traded. This is particularly relevant in a market for green products where the actual consumption of the green good is not necessarily aligned with the incentives of each individual private consumer.

In most traditional commodities *one* party, usually the seller, may have incentives to falsely claim that a product has a particular attribute. If this behavior is too prevalent then the

18 Fortunately today, despite a strong farm, policy discussion in Europe and the U.S. recognizes that corn-based ethanol has negligible GHG effectiveness vis-à-vis sugarcane (see Farrell et al 2006).

19 Stone (1911) citing the goals of the Chicago Board of Trade at foundation in 1848.

market may be less efficient, in the sense that a price premium does not create incentives for producers to deliver the quality demanded by buyers. In extreme cases the whole market for the hidden attribute can unravel because the buyers conclude that regardless of the premium they are willing to pay for a higher quality good, they will always get the low quality good (Akerlof, 1970).

But in this canonical case it is in the best interest of the buyer to get that information about quality. If customers are willing to pay enough, then many certification mechanisms may endogenously emerge, without too much need to design ex ante these institutions. An extreme example was counterfeit money in the US circa 1850. People were so eager to get valid currency that a market for certification appeared, despite no regulation by the Federal government and despite having more than 10,000 different currencies circulating (Mihm, 2007).

Analogously, in the XIX century the Chicago Board of Trade faced a huge challenge when the grain elevator replaced the usual bags for grain trading. While the elevators dramatically reduced shipment costs, they mixed grain that originated with many producers. Before these producers needed to preserve their reputation or pay for the damages. Now there was a danger of free riding on other people's reputation.

Interestingly, the Board developed new loading procedures so that even if trace-ability of the producer was lost, there is a guarantee of uniformity before loading the grain.[20] Moreover, in 1860 the Board separated the job of inspecting from the grain elevator operation, to give more independence and integrity to the people in charge of separating acceptable from non-conforming product. (Glaeser, 2007, from Cronon, 1991). Similar examples of institutions created to certify appear in many other commodities, including organic food and EUREPGAP quality certification.

The current ethanol markets also function in this way. Markets in United States and Sao Paulo manage with different sets of rules to guarantee that the commodity meets the minimum quality standards -- ensuring that dehydrated ethanol does not contain water, for example, and verifying that impurities do not exceed a threshold and that delivery rules are followed. So far, these mechanisms are built on the assumptions that the *final customer cares about the certifiable attribute*.

This is clearly different for green biofuels, where *both parties* may -- without further

20 The operating procedure for this included inspections by a third party as well as a set of internal controls to avoid collusion of the this certifier.

regulation -- make a side deal and circumvent the market. Unlike in previous cases, such a deal is profitable for the *coalition* of buyer and seller, like in illegal drug trade, at least in this dimension. As clear from this comparison, it is not obvious that a rule or regulation that works in a standard commodity market would work here.[21]

To make this market work one needs to focus on making every deal enforceable by a third party, which is a task that becomes increasingly complicated if we add too many requirements, especially if these new requirements are things the certifier agent cannot observe, like deforestation or impact on food prices.

In sum, certification is an economically sound tool to tell apart products with different attributes. But these should be attributes that can be observed by a certifier at some point in the value chain. Focusing on things that are not observable by a third party can not only increase the burden of requirements in these new areas, but also create mysterious and probably distortive ways to certify unobserved things, as it would be a requirement asking for biofuels produced in a give acre to not push the agricultural frontier as a secondary effect.

Organizing principle 3: Have as many (targeted) instruments as policy goals

It will be impossible to create a sensible green market if we pile the requirements of distinct and often contradictory policy goals onto the shoulders of bioenergy. Here we are simply restating Timbergen's (1952) conclusion that independent goals cannot be achieved without a sufficiently rich set of policy instruments to move them. As illustration, this principle says that if we care about forests, then we should design incentives to compensate the owners of that land to keep the forest. This is much more targeted and specific than trying to preserve a forest through bionenergy policy. Two different goals require two independent levers to achieve them.

Note, however, that there is an alternate approach to balancing the goal-instruments account. Rather than increasing instruments, one may need to reduce the number of goals. Prima facie we have nothing against this strategy, but after following the bioenergy debate for a couple of years, we believe that the goals that are linked to the industry are more likely to snowball than to be openly discarded from the policy arena.

21 In technical terms, the set of implement-able solutions for this case needs to be collusion proof, as in Tirole (1986), which certainly restricts even more the things we can ask the market to do for society.

Organizing principle 4: Minimize transaction costs, in a broad sense

Information in markets is like any other good --we want it as long as the additional benefit outweighs the additional costs. Thus, while full traceability of the product makes sense in an ideal world, the recommendation of economic analysis is to simplify regulations. As we will discuss in the next chapter, optimizing on simplification avoids the measurement of multiple steps in the value chain. If production and retail are enough to guarantee the maintenance of the green attributes, then a pragmatic global market does not need to go beyond it. Moreover, if traceability of the product is not essential, then one should opt to detach the certificate of compliance from the actual physical delivery. All of these "details" of the certification process dramatically shape a new green market with the practical challenges that global traders need to solve. Similarly, unless absolutely essential, one should avoid adding administrative burden at the customs level, as opposed to many WTO rules of origin.[22] Markets able to bypass border frictions are both more likely to be efficient and less biased against countries with poor state capacity.

Organizing principle 5: Create "scaffolding" to deal with uncertain regulation in complementary policy arenas

Finally, this leads us to the question of how biofuel regulation is embedded in a richer institutional environment. One example of this, at a practical level, is the inclusion of CO_2 transportation emissions in the measurement of biofuels' environmental impact. California's current biofuel proposal requires Carbon certificates from transportation. This may sound coherent since it focuses on the overall impact of putting the ethanol in, say, downtown Los Angeles. But it is only coherent in the *absence of other broader* Carbon regulations. For example, if an overall system of either Carbon Tax or Cap and Trade is available, truck drivers would *already* have incentives to reduce the Carbon burden of their operations.

One solution is to create what we call *scaffolding regulations;* a flexible set of norms that can accommodate to future changes in the rest of the regulatory environment. As illustration, if a global carbon tax becomes available, then local regulation can piggyback on it, rather than doubling the burden of taxation on energy transportation.

22 The World Trade Organization (WTO) has a series of regulations regarding what it means that a product is, for example, "Made in Mexico." In particular, to be "Made in Mexico" there needs to be at least a percentage of the value added produced in Mexico. Since this impact the import duties, the documentation of this origin happens at the border.

5. Some implications of these organizing principles

To ground these principles in the landscape of the current certification discussion, we discuss different applications related to *what*, *where* and *how* to certify.

5.1 The scope of certification

There needs to be a balance between making the biofuel "as green as we can" and making compliance *incentive compatible*[23] for all members in the value chain, including traders, transporters, buyers and auditors. As stated in the revelation principle,[24] the optimal policy cannot imply that people bypass the incentives targeted for them.

A critical issue is determining the scope of certification regarding second and *n*-th order impacts of energy consumption. Should the focus be *no dirty fuel in my car* or *no dirty production in the world?*

We have no argument against countries where consumers genuinely believe that what matters is that the ethanol burned in *their* engines does not come *directly* from a deforested acre. With these preferences for not being "involved" in, say, deforestation, then the right policy is to ask for direct certification of the producers' facilities and transportation. However, if countries have preferences for biodiversity and global thermal stability, then certifying only direct effects does not guarantee an improvement (e.g. Gallagher Review, 2008) because the compensating deforestation can happen in a place, production or country that is not certified. Production can be diverted to areas where Carbon and Biodiversity are not controlled.

This challenge is comparable to regulating child labor in the Bangladeshi garment industry. It is not obvious that banning child labor for a single brand that sells in the United States will reduce risky labor supply of these poor kids. Indeed, their next available job may be even more damaging. Similarly, certifying that a given acre was not formerly forested is not enough to combat deforestation. Arguably, the reason why this simple distinction is not evident in current bioenergy regulation is that it is very hard to monitor second order impacts.

More recently, environmental scholars have reported serious concerns over this Carbon and Biodiversity diversion (see Institute for European Environmental Policy 2008 report). Indeed,

23 *Incentive compatibility* means that after the incentives are put in place it is in the best interest of the people involved in the value chain to fulfill the requirements. Many times we think of self enforcing mechanisms, but command and control, if effective, is also a way to make compliance *incentive compatible*.

24 Myerson, R. 1979. Incentive-compatibility and the bargaining problem. Econometrica 47, 61–73.

measured quantities to give benefits pervaded the regulatory discourse both in California and in Europe. This, we believe, is a success of the widespread use of Life Cycle Analysis logic. Currently, for example, the European Commission is waiting for a report in 2010 in order to "*review the impact of indirect land use on greenhouse gas emissions*". This is a response to the criticisms that the regulatory framework was doing little to prevent Carbon and Biodiversity diversion. Similarly, U.S. and UK policies are being reviewed under this logic (see Gallagher, 2008).

However, the fact that we *measure* (average) life cycle impact does not imply that there are *levers* to solve the problem. The regulatory authorities are, indeed, between a rock and a hard place. On the one hand, secondary effects are pervasive, something that became even more salient in Europe after the news that palm for biodiesel was planted in areas previously covered by forests (see Rosenthal, 2007). On the other hand, these effects are fully indistinguishable from the pressure on forests and carbon stocks posed by food, economic development or wood production. Most of the diversion works though the price system: an extra demand for biofuels pushes land towards biofuels, increasing grain and cattle prices, which move the agricultural frontier even further out. This deforestation should be quantitatively similar to *any* other shock to grain scarcity, like an increased taste for beef. [25]

Adding up, it seems unlikely that biofuels were the main force explaining recent deforestation trends. As shown by Fischer et al (2009), the reduction in Amazonian forest is *an order of magnitude* larger than the entire expansion of sugarcane in Brazil. This sole figure suggests that to target *environmental externality displacement* a regulator will need *more instruments* than just a proof of "non-deforested land" origin for biofuels. [26] These additional goals may be addressed with new instruments. For example, an across-the-board carbon tax or a subsidy for biodiversity services can address part of the diversion problem.[27]

25 Very recently, the U.S. House of Representatives inserted a clause in the American Clean Energy and Security Act of 2009 prohibiting EPA from counting indirect costs. We are agnostic on whether this is a result of industry lobby or the recognition of the technical difficulties to disentangle the effect of a particular producer on the indirect externalities.

26 Even if some correction is needed for the counterfactual yields of other crops.

27 What is less obvious is how we can implement such a tax in a multi-jurisdictional setting.

5.2 The unit of certification: firm or country

Certification systems place the burden of proof at different scales, typically choosing either firms or countries. The decision should deal with both practical and incentive problems.

A first concern is that environmental externalities can be diverted from one place to another. In this scenario firm-level certification may indirectly promote deforestation[28] in other areas of the *same* country. In contrast, country-level certification would induce the negative externalities to move to *other*, non-certified countries. Thus, at least in this attribute, it is not clear that certifying countries is more effective in terms of achieving environmental goals.

Second, certified firms may internalize their reputation better than some countries. In particular, when it is privately costly to comply with regulations, there is a free-rider problem for firms when the certification is issued to the country. The country's certificate is a *public good* that not all firms have incentives to invest in, especially if the firm can cheat on the country's reputation, selling "dirty" biofuel and paying only a fraction of the social costs of destroying such reputation.

Third, state capacity is limited in much of the developing world. In these places, country level certification might be a *de facto* infinite tax on the production of biofuels for a green global market. Consequently, these areas may have relatively more incentives to sell "dirty" crops or devote land use to non-environmental objectives. The canonical case here is central Africa. While biologically suitable for the production of bio-energy, the State is unable to provide peace or rule of law. Since these services outrank the ability to monitor deforestation, we can hardly expect that an entrepreneur can overcome these weak state pathologies in order to produce and create jobs.

All these reasons suggest that, once we agree on the goals of the certification procedure, it is not obvious at what level the burden of certification should rest -- the country or the firm? There are examples grounded in well-argued economic rationale on both sides.

In cases with low ability to trace back production to the firm, like the beef industry in the near past, certification tends to happen at a country level. Similarly, when the extent of the externalities is national, this scale of certification is also preferred. One example is current practice for "Foot and Mouth Disease," a highly contagious viral disease of cows, sheep and goats. It is sometimes fatal for animals, but *it does not affect humans*. Another is the

28 Here we use deforestation as a shortcut of any other negative environmental externality.

Mediterranean fruit fly,[29] which damages fresh agricultural produce. Interestingly, many countries that depend strongly on these exports – such as Paraguay, Argentina or Brazil – have been unable to sustain full compliance in the country. As mentioned, this is likely to be due to the incentives to free ride on the country's reputation.

One way to bypass these kinds of problems has been to certify only some sub-national units (i.e. regions). These regions, if properly isolated, are the equivalent of an industrial zone, where a particularly relevant public input is provided in a targeted way.

The other extreme is certifying firms. In that case the firm is privately charged with documenting and enforcing compliance with standards. By design, this reduces the incentives to free ride. However, these systems do worst in dealing with externalities that cannot be monitored in the production site.

In cases where externalities (environmental or not) can be monitored in the site of production, firm-level certification is increasing. For example, through its network of accredited certifiers, ISO has made it possible for millions of firms across the globe to document their management practices regarding quality (ISO 9001) and the environment (ISO 14001). Similarly, the consortium of European supermarkets followed the same strategy to make sure that the food they sell is safe and follows good agricultural practice (EUREPGAP). In general, the availability of this type of certification for firms levels the playing field for the marginal entrepreneur in developing countries. [30]

Importantly, new innovations allow firm-level certification to be preferred in areas that were previously dominated by country-level approaches. Traceability systems now allow any member of the value chain to determine which firm originally produced a particular cut of beef or box of apples. The free riding problem is being reduced by putting identifiers in the boxes (and on the ears of cows) under the umbrella of a supply chain record keeping system; from seed to shelves in the supermarket. This option is particularly important for countries without a strong state capacity.

An interesting variation of the previous point is that using existing *average* figures for analyzing Life Cycle impact will not necessarily create incentives for new producers to improve. For example, an entrepreneur, in a high deforestation country, that optimizes on environmental

[29] *Ceratitis capitata.*
30 This firm level certification is also what guides the FSC standard for forests.

impact may not be rewarded for her effort. In an extreme example, even if a new farmer in such a country produces with zero CO_2 and causes no biodiversity effects, he will not be competitive because of the shared burden imposed by other producers in the value chain. In short, using GREET defaults for countries creates a free rider problem. In general, the more developed countries move regulation to national averages, the less likely it is that countries with poor state capacity can become competitive in these industries. Measuring overall effects seems to be a reasonable starting point for benchmarking, but the measures available – like GREET defaults - may not deliver the right incentives for the market.

In short, there are many incentive challenges of creating a market in a multi-jurisdictional world, particularly when forests and suitable areas are concentrated in countries with poor state capacity.

5.3 What information is essential to trace?

More information is not always better. Like any economic factor, the marginal value to the production chain of getting additional information should be lower than the marginal cost created by gathering that information. In particular, conditional on the regulatory goals, the lighter the regulatory structure, the greater the odds of compliance.

An initial question is whether we need green certificates to be physically attached to the product.

The successful experiences of traceability in the organic food industry and forest certification certainly suggest that this approach be taken seriously in other areas of debate such as green energy. But the characteristics of energy commodities differ in important ways. First, as mentioned, neither transacting party has baseline incentives to make sure that the product is actually “green.” Second, transportation of biofuels mixes production from different firms.

The current proposal in California recognizes this, making trade in certificates separate from the trade of the actual fuel. There is nothing in a particular ethanol gallon than can impact people’s welfare. Unlike in poisoned food, there is not an immediate need to over-trace its flow over the value chain. This California proposal is aligned with EPA’s proposal for the US (see Turner, Plevin O’hare and Farrell, 2006). What remains an open question is how to implement

these ideas in a multi-jurisdictional context, where not all countries can or want to participate.[31]

Another goal is to minimize the market's disruption at international borders. Interestingly, once we detach the certificate from the actual gallon of ethanol, the administrative burden does not need to be shouldered at the customs level.[32] Unlike many WTO regulations about proofs of origin, detached certificates can be controlled at the distribution point. As illustration, let's consider a producer of clean ethanol in Zambia. In the processing facility an accredited agency can certify that X cubic meters of ethanol were produced this month in compliance with a given standard. But after that, like in Carbon Certificates, the product and the certificate travel separately, so there is no need to keep traceability on which particular cubic meter was produced. The discipline in the system comes at the level of the distribution in final destination. A distributor that claims to sell Y cubic meters a year need to submit certificates, coming from everywhere in the World, indicating that for every cubic meter the firm bought one certificate. This certainly simplifies things.

In the recent California regulation part of this intuition is included, although this has not been highly publicized. To us these clauses in a regulation seems particularly relevant as a starting point to enable production in developing countries, where the state may not fully control their administrative boundaries.

Finally, regulations need to decide if monitoring would touch the whole chain or only the production and consumption extremes. As illustration, the most recent California Governor's proposal (2008) asks for Carbon certificates at every point in the value chain, as if in a value-added tax, where each successor has incentives to claim for the preceding discount. As discussed in the taxation literature, these mechanisms have some self-enforcing properties. These have proved to work well in environments where both buyer and seller have incentives to collude and not comply, although the evidence has been in a single jurisdiction. For the case of imported bioenergy, adding extra record keeping requirements to intermediate players can both block trade and induce collusion within the value chain. In short, adding requirements to intermediate players that are not under the umbrella of the same law may also increase the odds of failure of a certification system. Thus a cautionary approach to institutional design should consider both

31 In a nutshell, the Californian regulation (announced January 2007 and beginning in 2010) has a target of at least 10% reduction in lifecycle GHG of transport fuels by 2020. While each company must reduce by emissions by 10%, it can trade and bank "credits." Interestingly, these credits are detached from the actual gallon or biofuel.

32 Similar to other cases: Boyd et al 2003.

benefits and costs of further regulation.

6. Conclusion with remarks and conjectures for policy

There is a large potential for bio-energy as a new industry for some developing nations near the tropics. But that biological potential cannot be exploited without the existence of both a domestic business ecosystem that can nurture a complex production network, and a reliable international market for green bioenergy. Domestic markets are too small and too volatile to attract entrepreneurs to this industry without a minimum of coordination.

The creation of a global market for green biofuels is being affected, however, by a constellation of diverse and sometimes conflicting policy goals. In order to deal with this complexity, we outline five organizing principles that we later apply to the current policy discussion. A first principle is to build certainty in places where production is potentially viable. This implies, among other things, not biasing certification requirements against countries with poor state capacity. A second principle is that not everything is certifiable, so even if certification has an important rationale for improving economic transactions, it does so only if certifiers can observe what producers do. These principles, for example, point towards avoiding certification of biodiversity and other indirect impacts. Third is that to address issues not well handled by certification, like indirect impacts on forests and food, we need other instruments. That works better than forcing a certification system to distort incentives in order to imperfectly affect, say, forests. Fourth is to minimize transactions costs whenever possible. This implies certifying only the crucial steps in the value chain, to avoid making the burden of regulation higher than the benefits of an efficient production. The fifth principle recognizes that the current international environment for regulations *related* to biofuel, like a global carbon tax or a biodiversity subsidy, are currently incomplete. As a result one should look for *scaffolding regulations* that change conditional on the rest of the regulatory context. In this light, some proposals transitorily suggesting less targeted regulations, as in California today, recover an economic rationale because they recognize there are currently no appropriate global instruments to deal with, say, global carbon. Thus, asking the transportation system to pay for additional carbon credits is second best. While in a scenario with worldwide carbon tax (or cap and trade) the truck driver would already internalize the environmental costs of moving ethanol, this is not the world in which California is regulating today. The important thing is that this California proposal should be flexible enough to

adapt to future changes in the rest of the regulatory environment.

To conclude we conjecture ingredients for a proposal. We believe that a first priority in achieving efficient biofuel market regulation is to create an overall system of trading for Carbon and other Environmental Services, which greatly simplifies the job of biofuel-specific regulation. Interestingly, these can address their own goals without distorting the incentives of entrepreneurs to develop a new industry. In our view, having a good global carbon policy is a complement rather than a substitute for building a new green bioenergy market. A second ingredient is to promote firm-level certification as opposed to country-level. We think there are many reasons to believe that country level certification will become yet another non-tariff barrier, burying the potential for industrial development in countries with poor state capacity. Finally, we recognize that some jurisdictions in the world, like California, the US or Europe are regulating *assuming* an absence of global carbon trading. But since these Carbon markets are likely to come, our recommendation is to make scaffolding biofuel regulations that can work today, but can also smartly adapt to new market conditions. A global market for Carbon is not a substitute of a biofuel and forest certification, but a complement.

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