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Regulating a global value chain with the European Union's sustainability criteria – experiences from the Swedish liquid transport biofuel sector

David Harnesk [a, b, *], Sara Brogaard [a], Philip Peck [c]

[a] Lund University Centre for Sustainability Studies (LUCSUS), Box 170, 22100 Lund, Sweden
[b] Lund University Centre of Excellence for the Integrations of the Social and Natural Dimensions of Sustainability (LUCID), Box 170, 22100 Lund, Sweden
[c] The International Institute for Industrial Environmental Economics (IIIEE), Lund University, Box 196, 22100 Lund, Sweden

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A B S T R A C T

Despite promises that they can contribute toward more environmentally beneficial transportation there are many sustainability concerns about liquid transport biofuels. In response to pressure from civil society, the European Union (EU) has introduced sustainability criteria for biofuels. A hybrid regulatory system involving state and non-state actors stipulates that retailers and producers must comply to be eligible for fiscal support such as tax exemptions. Flexibility in the system allows choice between different means of compliance, including a range of voluntary schemes. We present an analysis of views within the Swedish liquid transport biofuel sector in 2012 – a year after the introduction of EU sustainability criteria. Using document analysis, official statistics, and a survey, we use four key structures of global value chains — input–output structure, territorial configuration, institutional framework, and firm-level chain governance structure — to structure an analysis of biofuel value chain coordination. This yields three main findings regarding how the Swedish liquid transport biofuel system operates within, and views, the new regulatory framework. Firstly that it uses a broad portfolio of feedstock mainly from within Europe, seemingly avoiding countries where any supply conditions may be in doubt; second, larger retailers and producers achieve compliance without the need to provide additional social sustainability information; third, that actors exhibit predominantly Eurocentric perspectives on sustainability, express confidence that their supply chains have strong 'sustainability performance' and desire long-term policy stability. We conclude that despite a deep critique of the sustainability of biofuels amongst civil society and academia, EU regulation allows for production systems that reflect a European- and climate change mitigation-centred view on biofuel 'sustainability'.

1. Introduction

Market-based instruments and hybrid regulatory systems involving both state and non-state actors are increasingly applied to address transnational sustainability issues. These approaches give rise to new forms of environmental authority and political space for myriad actors (cf. Cashore, 2002; Lemos and Agrawal, 2006; Sikor et al., 2013). The mechanisms included in the EU's sustainability criteria for bioliquids and transport biofuels (EU SC) is a key example. The EU SC applies mandatory criteria to regulate certain areas of environmental concern in the production of biofuels. However, actors such as fuel retailers, biofuel producers, third-party certification organizations, and local communities are often caught between conflicting interests and power positions. As a result, the transformational promises (and performance) of these criteria towards sustainability cannot be taken for granted (cf. Mol, 2010; Fortin, 2013). This study adds to this debate by presenting an examination of views held by firms that deliver liquid transport biofuel[1] (LTB) to the Swedish transport energy system. We consider

* Corresponding author. Lund University Centre for Sustainability Studies (LUCSUS), Sweden.
E-mail address: david.harnesk@lucsus.lu.se (D. Harnesk).

[1] Liquid transport biofuels include ethanol, and biodiesel (e.g. FAME, HVO, etc.) and other fuels that are used in combustion engines of vehicles either within low-level gasoline or diesel blends, or high-level versions such as E85 and B100 that are more dependent on more specialized combustion engines.

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their views of, and reactions to, the EU SC as important as they are effectively the 'gate keepers' for the Swedish LTB production and consumption system. This actor group owns and runs key production units and distribution platforms – their choices, and actions in response to policy interventions are thus crucial to the form and function of the Swedish system.

The EU SC was introduced simultaneously with the Renewable Energy Directive (2009/28/EC) and the Fuel Quality Directive (2009/30/EC). Together these set mandatory renewable energy targets and quotas to be met by all member states. This development is seen as the result of the European Commission (EC) efforts to harmonize renewable energy initiatives of EU member states (cf. Pacini et al., 2013). While such initiatives originally targeted improved energy security and rural development, changes were enacted in response to pressure from civil society regarding a range of biofuel sustainability aspects that became apparent during its development (ibid.). Contentious issues included: doubts regarding the GHG performance of biofuels when incorporating indirect land use change; the food-feed-fibre versus fuel-debate; whether support should be focused on conventional or advanced biofuel options, and disparate views regarding the role of international trade for developing countries (see Londo and Deurwaarder, 2007). As a response, the EC set out to create a 'sustainability safeguarding scheme' to mitigate adverse effects, and sought input from the public on its design (EC, 2007). Feedback to the process came predominantly from European actors, and although the EU had direct consultation meetings with representatives from Brazil, Malaysia and Mozambique (these countries being considered as potential exporters), the process has been criticised for insufficiently including the perspectives of countries in the Global South (Di Lucia, 2010).

According to the legal framework, only biofuels complying with the EU SC can be counted towards fulfilment of member state renewable fuel targets and be eligible for fiscal support such as tax exemptions. The regulatory scheme stipulates that economic operators which are eligible for tax exemptions are to comply with legislation. However, a degree of flexibility is granted regarding how they may demonstrate compliance. They are allowed to demonstrate compliance through national regulatory systems, any of seventeen (as of 2014) voluntary schemes, or through specific bilateral agreements (e.g. arrangements made with supplier countries).

Compliance to the EU SC has the potential for strong international implications as the EU relies on imports (of both biofuel, and feedstock) to satisfy its renewable energy targets (OECD and FAO, 2014a,b). Indeed, it is projected to become the world's largest importer of biofuels with an expected import of 15.9 million m^3/year by 2020 (Bowyer, 2010). Furthermore, statistical analysis by Hamelinck et al. (2013) showed that 43% (2.4 Mha) of the land used to produce the feedstock for EU-consumed biofuels in 2010 was outside of the EU territory. As the EU SC conditions need also to be fulfilled for feedstock and fuel produced outside the EU, the EU is partly promoting and regulating production beyond its own territory (Di Lucia, 2010). Despite the potential effect of the EU transport energy system on an increasingly diverse constellation of socio-environmental settings, we perceive that the actual impact of the regulatory system on the decision-making processes and operation of its key economic actors remains relatively unexplored.

This article draws on findings from an on-going research project that explores the broader effects of the EU SC from a Swedish perspective. It situates the development of the Swedish LTB sector in a European and global context. We examine aspects of international trade, and the operation and perceptions of actors complying with regulation, delivering LTB to the Swedish transport energy system. This includes retailers (that buy and distribute LTB) and producers (that produce and sell LTB). The study involved document analysis of legislation, official statistics and literature in the field, and a survey of Swedish LTB actors. Applying approaches defined within the global value chain (GVC) literature, we view retailers and producers as actors in charge of the coordination of their economic activities, directly involved in the links of exchange and transformation that result in a finished product delivered to a final market (Gereffi et al., 2005). Acknowledging critique within the literature of GVC research (cf. Ponte and Gibbon, 2005; Ponte and Sturgeon, 2014), effort has been focused on gaining an understanding of the operation of these actors within a broader regulatory context – in this case the Swedish transposition of EU's framework. A closer examination of the decision-making processes and operation of retailers and producers within the complex regulatory system provides a useful platform for discussing how LTB GVCs are coordinated. Here, Sweden serves as a relevant case with feedstock used for 78% of the total delivered amount (m^3) of LTB reported between 2011 and 2013 originating outside of its national borders (Swedish Energy Agency, 2014a). Sweden is also a suitable study object as: it has a long history of promoting biofuels (Eklöf et al., 2012); it was among the first to successfully transpose the EU SC (Hamelinck et al., 2013), and as it has a widely disseminated political goal to achieve conditions where its vehicle fleet is independent of fossil fuels by2030[2] (Government of Sweden, 2010).

This paper has the following structure. Section two delivers a conceptual frame for the analysis based on the four key structures of global value chains: input–output structure, territorial configuration, institutional framework, and firm-level chain governance structure. Section three then describes, and justifies, methods for data collection, data constructing methods and types of data. Official statistics are then used to delineate the general economic structures within which Swedish LTB value chains operate. Section four then explains how the EU framework is transposed into the Swedish legal context, together with survey findings regarding respondents' views on sustainability. In section five we provide a global value chain analysis of how LTB chains are coordinated, present survey findings, and then use a chain governance perspective to support a discussion of market operations and decision-making processes among retailers and producers in relation to their respective institutional frameworks.[3] In the concluding discussion we address the capacity, or incapacity, of the EU's regulatory system to address the social sustainability challenges associated with biofuel production and consumption.

2. Conceptual framework

While approaching global supply chains presents methodological challenges (cf. Boons et al., 2012), scholars of GVC have presented heuristic tools for structuring complex global economic activities in a bottom-up and actor-centred manner (Bair, 2009; Boons et al., 2012). Although the term 'value chain' refers to chain of activities when firms and labour–workers bring a product from its initial conception to final consumption, the GVC

[2] The political goal of a vehicle fleet independent of fossil fuels by 2030 is defined as having less than 50% of the final energy consumption for domestic transport comprised of fossil fuels (Government of Sweden, 2010).

[3] Here, 'Institutional framework' refers: EUs Renewable Energy Directive and associated sustainability criteria for biofuels and bioliquids; the Swedish transposition of EU SC; Voluntary Schemes used by Swedish retailers and producers; the proposed set of amendments directed at incorporating indirect land-use change (ILUC) caused by the expansion of biofuels into EU SC of 17 October 2012 (EC, 2012); a set of (adjacent) policy and market uncertainties – including price fluctuations of fossil fuels and feedstock, and increased requirements on social sustainability.

framework focuses on their overall structure in sectors producing for global markets (Gereffi et al., 2005). The assumption is that by homing in on the linkages between firms, and the power structures that regulate them, researchers can better understand, and even predict, what key parameters shape the outcomes of GVCs (ibid.).

As Sturgeon (2009) explored GVC literature in a theory building exercise, he summarized that GVCs can be analysed by looking into four key features of the associated chains, its: input–output structure, territorial configuration, institutional framework, and chain governance structure (see Table 1):

Input–output structure and territorial configuration are of a descriptive nature and refer to the (product specific) processes where raw materials are transformed into final products, and the different geographical scales involved. Understanding these features provides researchers with key descriptions of general and geographical economic structures associated with a particular sector that can otherwise be concealed by the commodity form. This is important because, for example, LTB can be produced from different types of feedstock, as well as in various socio-environmental settings, all of which are associated with different sustainability issues and challenges (cf. FAO, 2013). However, while these two structures provide important descriptive features, they alone provide little analytical insight to the relationships involved in shaping GVCs.

Institutional framework refers to the institutional contexts in which value chains are embedded, defining the 'rules of the game' that firms and industries must adapt to (Sturgeon, 2009). In GVC literature, 'institutions' are often explained in broad terms that covers the bureaucratic organizations, and rules that govern society through legislation and regulatory systems, as well as the realm of societal norms and expectations, that take part in shaping value chains (ibid.). The last key parameter, that of chain governance structure, places focus on how the value chain is coordinated and the firms involved. It involves the assumption that dynamics associated with global dispersion of economic production and its re-integration through inter-firm trade are shaped by the decision-making processes and strategies between firms (Gibbon et al., 2008). Here, Ponte and Gibbon (2005) argue that processes between firms, that define rules and conditions of participation in the value chain, are the key operational mechanisms of firm-level chain governance.

According to Gereffi et al. (2005), chain governance structure can be predicted by analysing the degree of three key determinants of a specific sector: complexity of transactions; the extent to which information can effectively be codified; and the capabilities in the supply base in relation to the requirements (see Table 2) (Gereffi et al., 2005). The degree of explicit coordination, tolerance of geographical distance between nodes of economic transactions, and power asymmetry within inter-firm relationships would differ depending on whether these determinants are high or low. Examination of inter-firm transactions can allow value chains to be ascribed one or several chain governance structure typologies; this helps us to theorize why some activities are more place-dependent and others more easily relocated. Table 2 shows five types of possible chain governance structures for GVCs: 1/market, 2/captive, 3/relational, 4/modular, and 5/hierarchy. Generally, it is only in the hierarchy mode that GVC can be viewed as vertically integrated (with large and dominating retailers defining the rules of the chain) and only in the market mode where transactions can be considered free from the influence of particular firms, and predominately governed by price. The remaining three are all organised as production networks with varying degrees of power asymmetry. Captive chains refers to industries were suppliers primarily produce or sell a product for specific retailers. This dynamic is often related to stringent requirements from retailers and has the consequence of encouraging transactional dependency (e.g. the automobile industry). Relational chains refer to industries where considerable information is communicated back and forth, and where retailers and suppliers are mutually dependent on each other. This dynamic is generally attributed to sectors where product specifications cannot easily be codified (e.g. the fashion apparel industry). Finally, modular chains include retailers dealing with highly competent suppliers, capable of switching partners. This is typical of industries where even complex information can be transferred easily via product standards (e.g. the computer industry).

3. Data construction methods and types of data

In this article, we relied on three data construction methods: a document analysis of legislation,[3] an analysis of official statistics, and a survey study in 2013 sent out to all retailers and producers delivering LTB in Sweden during 2012.

Table 1
Four key structures of global value chains. These structures have their origin in the global commodity chain-literature, but were expanded upon to cover findings developed by the global value chain-literature. The column 'Analytical orientation' consists of interpretations of the authors of this article. Based on summary by (Sturgeon, 2009).

Key structure	Main feature	Analytical orientation	Potential parameters of relevance in the liquid transport biofuel GVC
Input–output structure	Describes the process of transforming raw materials into final products.	**Material and spatial organization:** Describes the geography and material characteristics of linkages between nodes in the chain of value added activities.	Feedstock source-countries, transport infrastructure morphology, transport and transformation modes, scale and nodes, and transformation nodes.
Territorial configuration	Describes the different geographical scales involved.		
Institutional framework	Describes the institutional context in which the organization and the operation of value chains are embedded.	**Institutional:** Concerns the role that institutions play in how inter-firm relationships and industrial location is structured.	Relationships between the state (e.g. government bodies, regulation), economic actors (e.g. feedstock producers, transporters, transformers, certification organizations), and civil society (e.g. local communities, environmental NGOs).
Chain governance structure	Describes how and to what extent the value chain is controlled by particular firms.	**Power:** Analyses how power is distributed and exerted among firms and other actors in the global value chain.	Economic power of actors part of (or aiming to be part of) the GVC, their relationship to incumbent actors, and the potential synergies or competition with existing actors.

Table 2
Key determinants of global value chain governance (Gereffi et al., 2005).

Chain governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply base	Degree of explicit coordination and power asymmetry	Tolerance of distance
Market	Low	High	High	Low	High (Global)
Modular[a]	High	High	High	↕	↕
Relational[a]	High	Low	High		
Captive[a]	High	High	Low		
Hierarchy	High	Low	Low	High	Low (co-located or internalized)

[a] Rows with a grey background are comprised of global value chain governance structures organised as networks.

Based on the document analysis we delineated salient aspects of regulation for retailers and producers in Sweden related to the potential impact of the EU SC on their operation. Official statistics on the characteristics of LTB delivered in Sweden were collected, summarized and visualized in order to describe the general features of their input–output structure and the territorial configuration, as well as to the chosen means of compliance within the system.

Primary data consisted of a survey of which the main aim was to obtain insights into whether the EU SC had affected how LTB GVCs in Sweden are coordinated by economic actors: understood as the decision-making processes and operation of retailers and producers complying with the institutional framework. Survey questions were inspired by policy research presented by Stupak et al. (2012) but expanded in order to include sustainability issues addressed in the extant EU-biofuels literature (cf. FAO, 2013). The survey, conducted in Swedish, consisted of a set of themes (each with a different underlying rationale) with questions about the perceived impacts of the EU SC, market and policy dynamics on their operation, and also about values, including views on sustainability. Many questions were posed as rating scales, in degrees of 'importance', 'impact', or 'satisfaction' ranging from (1) 'None at all', (2) 'Small', (3) 'Moderate', (4) 'Large'/'Significant', and (5) 'Very large'/'Very significant' in relation to their operation. Most questions also included open ended comment boxes to allow for clarifications. Prior to issue in a web-based survey tool, the survey was sent for review/comment by two key bioenergy organisations: the Swedish Energy Agency and the Swedish Bioenergy Association and adjusted according to feedback. The target group for the survey included all economic operators that had fulfilled legislative requirements in 2012, 57[4] firms in total (see Swedish Energy Agency, 2013). Survey request e-mails were sent out to these 57 firms on the 20th of May, 2013, and were followed up with two reminders (after 7 and 14 days). A final attempt to obtain participation was then conducted in mid-June 2013 via a round of telephone calls directly to survey recipients. In total 12 firms responded, a 21% response rate – however, together these firms delivered roughly 80% of all LTB reported for Sweden in 2012.[5] The survey was most commonly completed by managerial staff responsible for reporting in accordance with the legal framework. As survey responses contains (potentially) sensitive business information such as long-term strategies and value chain characteristics of individual respondents, we only refer to respondents as either 'retailers' {R} or 'producers' {P} in this discussion.

Of the 12 responding firms: seven were categorised as retailers and five as producers – although one engages in both activities. The relatively high representation of economic actors in terms of share of LTB market and the relative low response rate in terms of total firms reflects that smaller retailers and producers did not participate in the survey. While this may be a result of insufficient personnel resources, reasons for non-response were not further investigated. Hence, while the limited set of informants poses a limitation, in that responses cannot be viewed as representative of the total group of actors studied, the views expressed in the survey do reflect the majority of the LTB sector itself. It should be noted that survey responses (taken to represent the views and experiences of individual firms that participated) were qualitatively analysed (including when they deviated from the typical response) together with official statistics and legislation through the conceptual frame provided by the GVC framework.

4. Results

The result section is structured according to the four key structures of global value chain approach as outlined in Table 1.

4.1. Input–output structure and territorial configuration – liquid transport biofuels delivered in Sweden

Retailers and producers of LTB delivered ethanol and biodiesel to the Swedish transport energy system (see Table 3). The total amounts have continued to grow since 2003, while the largest expansion thus far has been between 2011 and 2013, mainly as increased volumes of HVO biodiesel (see Fig. 1). Statistics disclose that these biofuels have been produced from 16 different types of feedstock, including starch- and oil-based crops such as wheat, corn, sugar cane, canola, and palm-oil, and to a lesser extent from residues such as tall-oil and slaughterhouse waste (see Table 3). Increasingly, LTB delivered in Sweden has been produced from residues or waste, mainly biodiesel produced from tall-oil and slaughterhouse waste (see Table 3). Overall, biodiesel is predominantly used for low-admixture diesel blends, and seldom found as high-level versions such as B100 (Swedish Energy Agency, 2014b). Ethanol, on the other hand, is both consumed in low-admixture blends together with gasoline, as well as high-level blends such as E85 and ED95 (ibid.).

The GHG emission reduction performance, an important metric within the legal framework (explained in section 4.2), of these biofuels differed. The canola-based FAME delivered in Sweden has hovered around 40% reduction, while ethanol and HVO were above

[4] During 2012, there were an unknown number of retailers and producers of that reported verified amounts of LTB late, so the numbers shown in the annual report is slightly lower than the actual delivered amount.

[5] This percentage was confirmed through collaboration with the Swedish Energy Agency, and is based a calculation made by the Swedish Energy Agency of the total amount of delivered LTB (including ethanol, FAME, HVO and ETBE) of the 57 retailers and producers featured in the annual report, and a list of names of the economic operators that had responded to the survey provided by the authors of this article.

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Table 3
Characteristics of verified amounts of liquid transport biofuels delivered in Sweden during 2011, 2012 and 2013.

	Year	2011	2012	2013
Total verified energy amounts of transport biofuel[a] (GWh)	Ethanol	2274 (38%)	2253 (32%)	2060 (21%)
	FAME	2183 (36%)	2481 (35%)	3009 (31%)
	HVO	320 (5%)	1367 (19%)	3729 (39%)
	Total amount	6061 (100%)	7061 (100%)	9680 (100%)
Average GHG reduction[b]	Ethanol	62%	65%	66%
	FAME	38%	40%	43%
	HVO	88%	85%	81%
Feedstock used (m^3)	Ethanol	Wheat (41%), corn (30%) and sugar cane (12%) – total of 10 different types of feedstock used.	Wheat (53%), corn (30%) and grain (5%) – total of 10 different feedstock used.	Wheat (35%), corn (23%), sugar cane (15%), and triticale (15%) – total of 8 different feedstock used.
	FAME	Canola – almost entirely	Canola – almost entirely	Canola – almost entirely
	HVO	Tall oil – almost entirely	Tall oil (44%), vegetable-based or animal fat-based oil (24%), slaughterhouse waste (22%), and palm oil (10%).	Slaughterhouse waste (51%), tall-oil (26%), and palm oil (19%).
Feedstock country of origin (m^3)	Sweden	22%	23%	19%
	Europe	86%	89%	77%
	Total amount of countries	24	30	36
Feedstock for transport biofuel[a] consisting of residues or waste (GWh)		8%	20%	31%

[a] The category **transport biofuels** also includes biogas in gaseous and liquid form.
[b] Based on reported calculations, and when compared with fossil fuel default value, in accordance with regulation.
Source: Compiled information based on annual reports from the Swedish Energy Agency (2012a, 2013, 2014a).

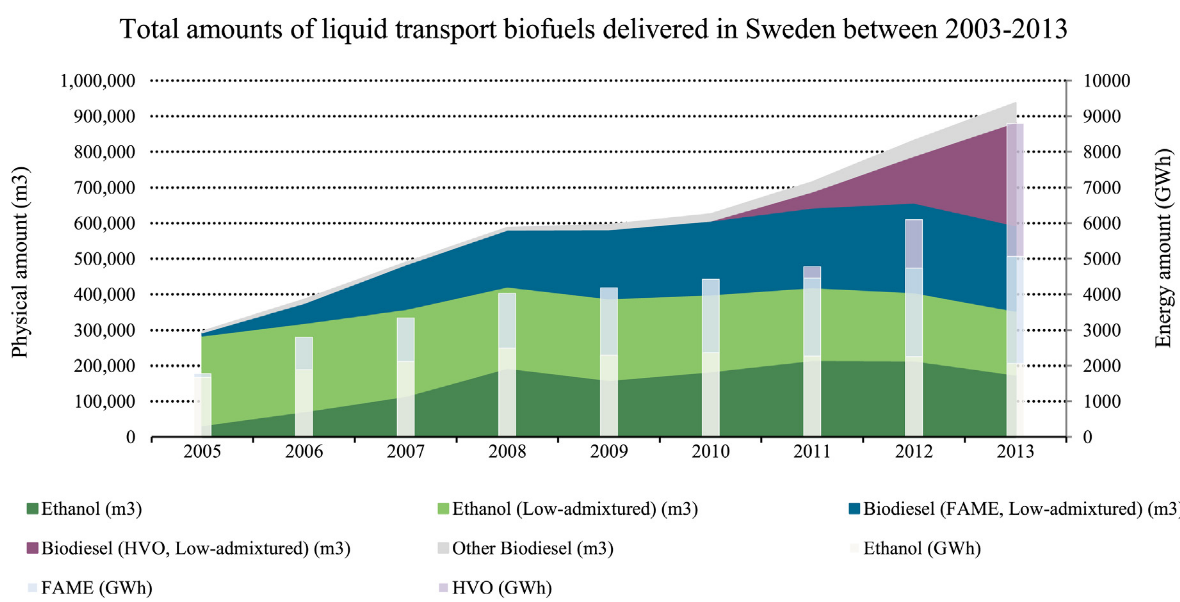

Fig. 1. Total amounts of liquid transport biofuels delivered in Sweden between 2003 and 2013 (m^3 and GWh). Data for the period 2011–2013 is based on Swedish Energy Agency (2012a, 2013, 2014a) whilst the remaining period relies on data from (Swedish Energy Agency, 2014b).

60% and 80% respectively according to the calculation methods of the legal framework (see Table 3).

The official statistics disclose where feedstock has been cultivated, or where residues have been disposed of in aggregated form, hence not where the fuel is produced. Feedstock for LTB delivered in Sweden has mainly been in European countries (see Table 3). The number of countries where feedstock had its origin has increased with the growth of the sector. In 2011, feedstock originated from 24 different countries but no feedstock originated in the Pacific region, almost none in Asia, and very little from South America (see Fig. 2). In 2012, amounts delivered by the survey population, countries were still mainly EU member states, however with more feedstock originating in Australia and South East Asian countries, and less from South America. In 2013, feedstock had its origin in 36 different countries. This period was the first where the growth of feedstock originating in non-European countries was larger than European, much due to the large increase of FAME feedstock cultivated in the South Pacific, HVO feedstock originating in Indonesia and Malaysia (presumably palm-oil), as well as the resurgence of ethanol produced from feedstock in Central- and South American countries (see Fig. 2). During this year, several new suppliers of smaller amounts of feedstock used for HVO were also introduced, such as the British Virgin Islands and New Zealand (Swedish Energy

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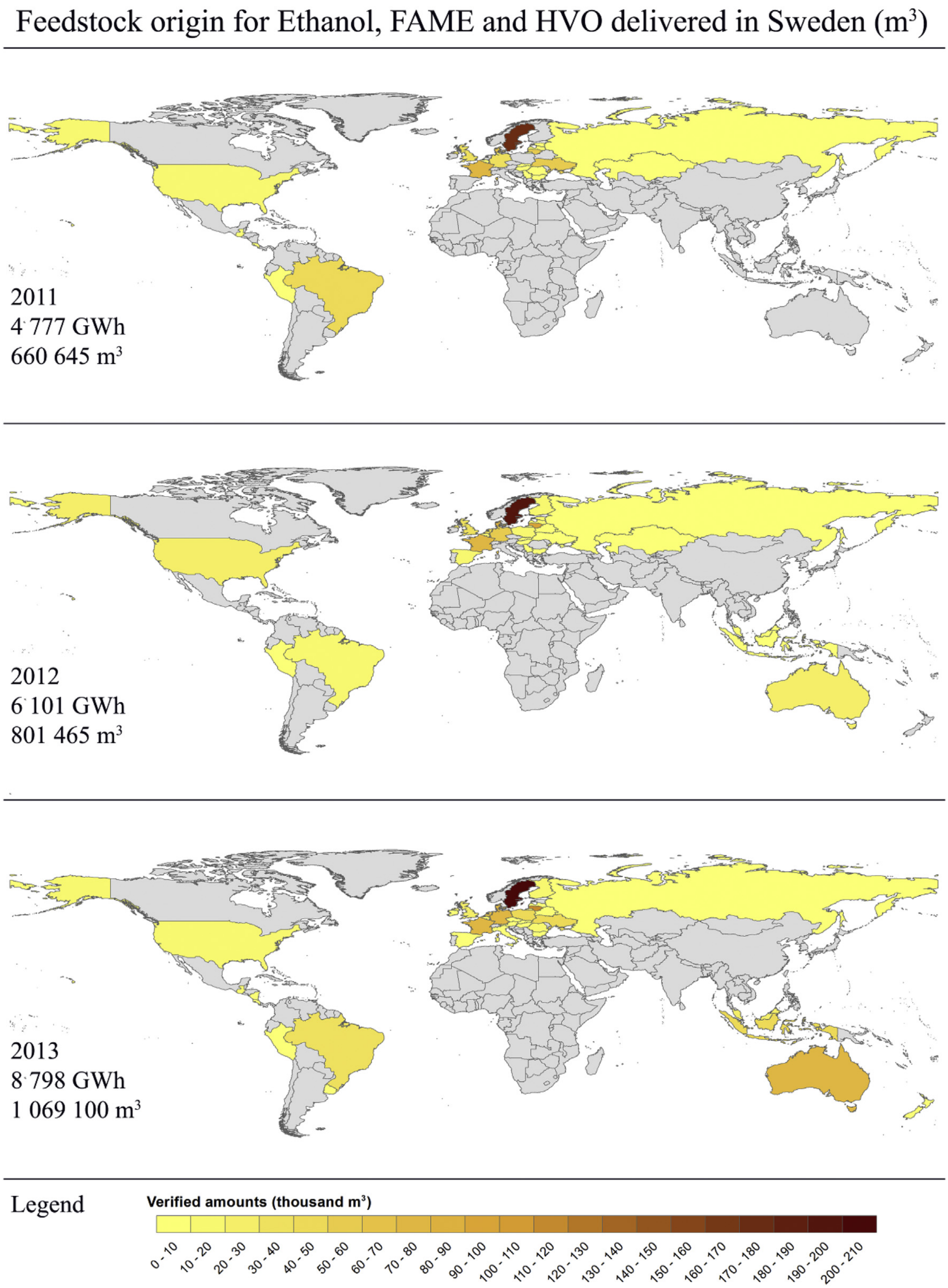

Fig. 2. Polygon-based maps over countries of feedstock origin in terms of verified amounts (thousand m^3) of liquid transport biofuel between 2011 and 2013. Graphic is based on compiled information from annual reports (Swedish Energy Agency, 2012a, 2013, 2014a).

Agency, 2014a). No flows from any countries on the African continent were found during the period with available data. It should be noted that throughout these three years only flows from four countries (Afghanistan, Costa Rica, Estonia and Serbia) have been disrupted for a one year period.

4.2. Institutional framework — EU regulation on biofuel ‘sustainability’ in Sweden

This section details the regulatory system of the EU SC in Sweden. It presents the requirements included in the national system;

Table 4
Overview of GHG thresholds and land use-requirements included in EU sustainability criteria for transport biofuels and bioliquids (EC, 2009).

GHG emission reduction requirements	Biodiversity requirements	Carbon stocks requirements
Biofuels must reduce GHG emissions throughout the production chain, relative to replaced fossil fuel by 35% and: − from 2017, ≥50% − from 2018, ≥60% for production units started after Jan. 2017	Feedstock may not come from land categorised as high biodiversity after January 2008, including: − Primary forest − Legal nature protection areas − Grasslands of high biodiversity	Feedstock may not be grown on land with high soil carbon stocks, including: − Wetlands in accordance to the Ramsar Convention − Continually forested land with >30% canopy cover − Land with 10–30% canopy cover − Peatland

social sustainability requirements included in voluntary schemes used in Sweden; details of the EU policy debate on indirect land-use change, and findings from the survey that relate to how respondents view sustainability.

4.2.1. EU's sustainability criteria in Sweden

The mandatory requirements of the EU SC focus on climate change mitigation. They include minimum thresholds for GHG emission savings and a set of land criteria that stipulate that biofuels derived from lands of high soil carbon stocks and biodiversity are ineligible for subsidies (see Table 4). These requirements, included in the EU Renewable Energy Directive (EC, 2009), were transposed to Swedish legislation through the legal framework referred to as act (2010:598) on sustainability criteria for transport biofuels and bioliquids, and amendment act (2011:1065). Requirements must be met throughout the entire 'fuel production chain', defined as "the process of production beginning with the cultivation of biomass, including the production of manure for cultivation, and lasting until combustion of the biofuels or bioliquids" (2010:598).

Procedurally, the Swedish transposition requires that economic operators with reporting obligations[6] apply for a 'sustainability decision' that can only be issued by the Swedish Energy Agency (SFS, 2011a). To be eligible to apply for a sustainability decision, retailers and producers eligible for tax exemptions need to have: a) a verification system covering each fuel production chain handled by the system assuring requirements are met, and b) a contract with an independent third-party auditor that has audited their verification system and will continuously audit their operation as a part of the review process. The verification system must be based on and include a risk assessment with internal procedures deemed insufficient to ensure that requirements are met throughout the fuel production chain. It must also include sampling procedures, deviation management, and written guidelines and procedures, as well as explanations of how GHG emission savings are calculated.

GHG emission savings and carbon stock calculations can be calculated by using predetermined reference values, partial reference values, or by actual calculation, depending on the circumstances of the fuel production chain (STEMFS, 2011:2). For example: reference values can be used when feedstock has been cultivated outside of the EU, but not if emissions have occurred due to direct land-use change of land with carbon stocks (Swedish Energy Agency, 2012b).

These fuel characteristics are reported through a mass balance system, where fuel and feedstock can be mixed as long as each portion and its characteristics can be traced. Nevertheless, there are exemptions for when and what characteristics need to be included. For example: land-use change does not need to be taken into account for waste and residues; and land criteria are not mandatory for waste and industrial residues but must still be met for residues originating from agriculture, forestry, aquaculture or fishery (Swedish Energy Agency, 2012b).

If a retailer or producer opts to certify their fuel with a voluntary scheme (see 4.2.2), they must still have a verification system in order to be eligible for a sustainability decision. However, then the verification system needs only to cover parts of the fuel production chain that is not covered by the voluntary scheme (such as the transportation-, storage- and distribution phase).

Finally, LTB from retailers and producers with a verification system that have attained a sustainability decision are considered to comply with regulation, and their fuel is referred to as sustainable in official government reports.[7] Verified quantities of biofuels and the characteristics of each consignment are then annually reported to the Swedish Energy Agency – who then publish an annual report on the development of biofuels and bioliquids in Sweden (c.f. Swedish Energy Agency, 2012a, 2013, 2014a). Each economic operator reports annually unless significant changes are made in the operation of retailers and producers – such as the introduction of LTB not covered by their verification system.

In summary, firm-level chain governance for LTB within this regulatory system involves complex transactions that can easily be codified (as the EU market follows the same standard). It is therefore likely that these chains can be attributed to the captive or modular chain governance structure. However, which of the two would depend on the capabilities of suppliers to abide to transactional requirements.

4.2.2. Voluntary schemes used in Sweden

Another means of compliance is to certify biofuel with any of the now 19 ratified voluntary schemes (EC, 2015a). The standards of these certification systems consist of principles agreed upon by the standard setting parties, that have then been translated into criteria, which determine which results are to be met in order to be certified (Van Dam et al., 2010). Voluntary schemes can be used as means of compliance among all member states for 5 years after being ratified (EC, 2011), and a member state may not demand further proof of compliance from these organizations during this period (Swedish Energy Agency, 2012b).

The voluntary schemes must include the same requirements as the EU SC, but are allowed to include additional sustainability criteria: such as soil-degradation, water use and water quality;

[6] Economic operators with reporting obligation are those who: "a) are taxable for fuel that is partly or completely comprised of biofuel or bioliquids according to Chapter 4. Energy Tax Act 1994:1775; or b) are economic operators that in their business activity use biofuel or bioliquids that is neither partly nor completely taxable according to the Energy Tax Act" (Swedish Energy Agency, 2013).

[7] Nb. verified amounts of liquid transport biofuels must also be reviewed and audited at several different steps and instances; first, mandatory sampling producers should be conducted by the economic operator, an independent auditor, or other third-party actor. Second, smaller deviations noted by the economic operators must be registered within the verification system while for example changes in contracts with sub-suppliers and procedures when no longer covered by the verification system – need to be reported to the Swedish Energy Agency and require the economic operator to revise their procedures. Third, the verification system must be audited by an independent auditor prior to applying for a sustainability decision, as well as during the regular review process conducted by the Swedish Energy Agency.

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Table 5
Share of transport biofuel (including biogas in gaseous form) delivered in Sweden verified through voluntary schemes (Swedish Energy Agency, 2012a, 2013, 2014a).

	2011	2012	2013
Certified amounts of biofuels	27% of the total verified energy amount of transport biofuel was certified.	39% of the total verified energy amount of transport biofuel was certified.	33% of the total verified energy amount of transport biofuel was certified.
Voluntary schemes used	*Voluntary schemes used unknown (not included in annual report)*	*REDcert (21%), ISCC EU (13%), ISCC DE (2%), Ensus (1%), RSBA (1%), 2BSvs (1%), Bonsucro EU (0%)*	*ISCC EU (31%), REDcert (2%), Bonsucro (0%)*

impacts on labour rights, livelihoods, migration and social justice; and competition with food. There is broad consensus that all these items also represent key sustainability challenges faced by the global biofuel production and consumption system (c.f. Worldwatch Institute, 2007; FAO, 2013; Rosegrant and Msangi, 2014).

In Sweden, 32% of the total fuel energy amount delivered during 2011–2013 was certified with voluntary schemes, predominantly with REDcert and ISCC EU (see Table 5) (Swedish Energy Agency, 2013). These two standards have no feedstock restrictions and were developed in Germany – the initiator behind REDcert being an industry consortium (REDcert, 2014a), and ISCC EU being a consultancy company (ISCC, 2011a). REDcert, can only be applied for feedstock produced in EU member states, Ukraine and Belarus[8] (REDcert, 2014c), whilst ISCC includes no such restriction (ISCC, 2011a).

REDcert includes no additional social sustainability requirements (REDcert, 2014b). ISCC EU has two principles that includes social sustainability criteria; concerning working conditions, and human-, labour- and land rights (ISCC, 2011b). These two principles include 34 criteria, 10 of which are mandatory (ISCC, 2011b). The mandatory requirements of the latter principle are based on the fundamental ILO conventions (ISCC, 2011c). Compliance with the criteria on working conditions is to be verified by an assessment of internal documents, interviews with personnel about knowledge levels of work-related accidents and safety measures, and an inspection of whether personnel, when necessary, are using protective clothing (ibid.). In total, ISCC includes 48 non-mandatory criteria, where a total of 60% must be met in order to be eligible for certification. Important to note is that the two principles that include social sustainability criteria are judged to be satisfied if feedstock has been produced in a country that has ratified associated ILO conventions (ISCC, 2011b). For example, out of the 39 different countries that had produced feedstock used for LTB delivered in Sweden 2011–2013, only Afghanistan, Australia, Brazil, Malaysia, New Zealand, and USA had not ratified all 8 of the fundamental ILO conventions (ILO, 2014).

In summary, if feedstock is produced in a country that has ratified associated ILO conventions, there is little difference between the Swedish national system and verification schemes used by firms in regards to additional social sustainability requirements.

4.2.3. Introducing the October 2012 proposal on indirect land use change

The EU's ambitions to scale up the biofuel production and consumption system have also raised concerns regarding indirect land use change (ILUC). ILUC refers to the change in land use occurring when land previously used for food production shifts to biofuel production, thus in turn seen to move the food production to new previously un-cultivated land. Incorporating this change in land use into GHG calculation methods within the current regulatory system would bear with it that the (nominal) climate change mitigation capacity of biofuel produced from food-based crops would be (significantly) reduced.

In October 2012, the EC proposed a set of amendments directed at incorporating ILUC caused by the expansion of biofuels into the EU SC (EC, 2012). The proposed amendments included setting a cap on food-based biofuels allowed to be used in meeting mandatory targets (ibid.). It also introduced a system where biofuels based on waste and residues could be double- and quadruple-counted for meeting mandatory targets, while also altering the default GHG savings calculations for biofuels based on cereal, sugar and vegetable oil feedstock (ibid.). Finally, it included an increased threshold for GHG savings for biofuels from production units starting operation, beginning 1st July 2014 (ibid.).

However, this proposal was rejected, and the most recent version that has emerged through the succeeding policy process included, amongst other, no altered default GHG saving calculations for food-based biofuels, but obligated fuel providers and member states to instead report emissions that might be caused by ILUC (for more see EC, 2015b).

4.2.4. Exploring firms' views on ‘sustainability’

Sustainability issues for LTBs – with globally dispersed production and consumption system, and many possible feedstock materials – are inherently complex as they involve many, and vastly different, socio-environmental settings. As individuals, actors and organisations have their own interests and interpretations of what is sustainable, we asked the respondents to prioritize the four sustainability aspects they considered most important to ensure the sustainability of biofuels (see Table 6). Asking respondents to only choose four aspects comes with some limitations. Valuing a certain sustainability aspect as important does not imply that one does not value another as (almost) equally important.

Results were diverse, and showed mixed views on biofuel sustainability. Many actors viewed technically oriented sustainability aspects – many of which interconnected – among the most important: such as lower GHG emissions, fuel energy balance, economic efficiency, and air pollutants. Many respondents, however, also viewed various social sustainability aspects among the most important for ensuring the sustainability of biofuels: such as livelihood impacts and rural development, labour- and human rights, and the competition with food. Further it was found that water use and – quality, together with economic equity, were not considered among the top four important aspects by any of the respondents.

When specifically asked whether social sustainability aspects should be included when monitoring transport biofuel sustainability; five producers and one retailer thought that it ‘should be included’, one producer thought that it ‘should not be included’, and three did not to answer. Two retailers answered that they ‘do not know’ – one of them commenting that meeting these requirements for fossil fuels would also be necessary {R5}. One respondent commented that requirements on social sustainability

[8] REDcert allows for LTB to include consignments produced from feedstock outside EU if such consignments are certified with another voluntary scheme ratified by the EC (REDcert, 2014c).

Table 6
Responses to the question "Please select the four sustainability aspects that you consider the most important to ensure the sustainability of biofuels." (n = 10). 'R' stands for 'retailer', and 'P' stands for 'Producer – one of which does both. Categories for essential sustainability aspects for biofuels were based on work by (FAO, 2013).

Sustainability aspect commonly associated with transport biofuels	*R*	*R*	*R*	*R*	*R*	*R*	*P*	*P*	*P*	*P*	*N*
Lower GHG emissions	✓		✓	✓	✓	✓	✓	✓		✓	8
Air pollutants	✓	✓		✓					✓	✓	5
Economic efficiency	✓		✓				✓		✓	✓	5
Labour – and human rights	✓	✓		✓				✓			4
Livelihood impacts and rural development		✓		✓		✓			✓		4
Competition with food		✓			✓				✓		3
Fuel energy balance					✓			✓		✓	3
Biodiversity			✓				✓				2
Effects on land use and soil productive capacity			✓				✓				2
Land – and resource rights					✓			✓			2
Economic equity											0
Water use and – quality											0
Other (comment)											0

were not necessary for feedstock produced in Europe {P35}. Responses to the perceived impact of any eventual requirements on social sustainability on their operation shared the same features, where three producers and two retailers perceived it as a 'moderately' impactful or less, while many opted not to take a clear stance (see Fig. 3). Finally, when asked to summarize, all but one respondent {R31} had between 'average' and 'very high' confidence that existing legislation and standards, together with guidelines within their organisation, is sufficient to assure the sustainability of transport biofuels.

We also asked if respondents thought there is a need for EC's October 2012 proposal, directed at incorporating ILUC, to ensure that transport biofuels are indeed sustainable. Responses varied, including proponents and opponents, as well as actors of more nuanced and wavering positions. One retailer was positive toward increasing the GHG threshold to 60% but very critical about other proposals – arguing that ILUC as an issue must be dealt with where unsustainable land use practices are occurring and not limit the cultivation of energy crops in Europe {R5}. The most important aspect, according to this retailer, is to further reduce GHG emissions, and promote fuels with good climate mitigation capacity {R5}. Another retailer argued that the intentions of EC were unclear, and that the amendment would halt investments in renewable energy, and would also deliver harsh blows to the forestry-oriented LTB sector found in Sweden {R32}. A producer commentated that policies should be broader and more all-encompassing and effort should be put towards reducing CO_2-emissions and coordinating political goals not only within EU but also globally {P14}.

Although this study does not elucidate how they define it, nor their responsibility in assuring it, respondents seemed generally confident in the social sustainability performance of their LTB. Results were also indicative of that major share-holding firms do not view voluntary schemes as means to go beyond the mandatory climate change mitigation-oriented requirements. This is also indicated in the instances where voluntary schemes had been used, where firms predominately relied on LTB certified with REDcert (which has a EU focus and does not include any social sustainability criteria), and ISCC, which system was flexible and socially oriented principles were deemed fulfilled if fundamental ILO conventions had been ratified.

Survey responses have been interpreted as having a pervasively Eurocentric perspective – both when discussing legislation and sustainability. It can in part be explained by feedstock mainly having its origin in Europe. Also, actors' weighing various sustainability aspects differently is likely connected to retailers and producers have varying degrees of prior experience, different points-of-departure and interests, and deal with LTBs produced in different socio-environmental settings associated with different sustainability issues.

4.3. Chain governance structures – regulating the coordination of the Swedish liquid transport biofuel sector

4.3.1. Regulatory compliance and chain governance structures

Regulatory compliance within the Swedish transposition of the EU framework requires firms to attain a sustainability decision for their LTB. This process introduced technical and procedural requirements and thus new transaction costs to cover items such as additional administration and certification fees. Here, every type of data necessary to meet requirements was viewed as 'moderately difficult' to gather, and the added administrative burden was generally perceived by respondents to be a 'significant' cost. Three retailers and three producers had prior experience with investigating 'sustainability characteristics' of LTB; such as various technical life-cycle analysis approaches and documents such as strategic management plans {R5, P35, P1}.

All respondents had verified their LTB through the national system. However, three producers had also verified compliance through voluntary schemes. These three indicated that 'gaining access to new markets', closely followed by 'sustaining existing market shares' were 'important' drivers for certifying LTB with a voluntary scheme. As for retailers, three responded that voluntary schemes provide 'no significant market advantage', and 'administrative difficulties' were 'important' or 'very important' reasons for not relying on them as means of compliance.

Six firms responded to a question about important factors for potentially choosing to certify LTB with voluntary schemes. Responses showed that 'price setting', 'increased market shares' and 'gaining entry to new markets' were considered equally important drivers as 'green entrepreneurship'.

All producers indicated that they gather information on fuel characteristics for compliance from within the company, while retailers relied on external contracting to gather the necessary data to varying degrees ('mainly internally', 'half–half', or 'mainly externally'). One retailer expressed that they focus on trade and get all relevant data from their suppliers. Another retailer – buying LTB from other retailers (and produced from feedstock originating in 12 different countries) – explained that they were *forced* into depending on information provided by their supplier as they were unable to verify the information themselves {R31}. A similar logic was found in other survey responses, through comments. Here, one retailer commented that the risk of falsified certification, caused by corruption somewhere in the supply chain, together with a more general risk of requirements not being met, had led to a decision-making process based on such risk assessments {R32}. Another retailer commented that they had ceased import of LTB from countries that had not implemented the EU SC as they could not supply a verified product anymore {R5}. One producer, on the other

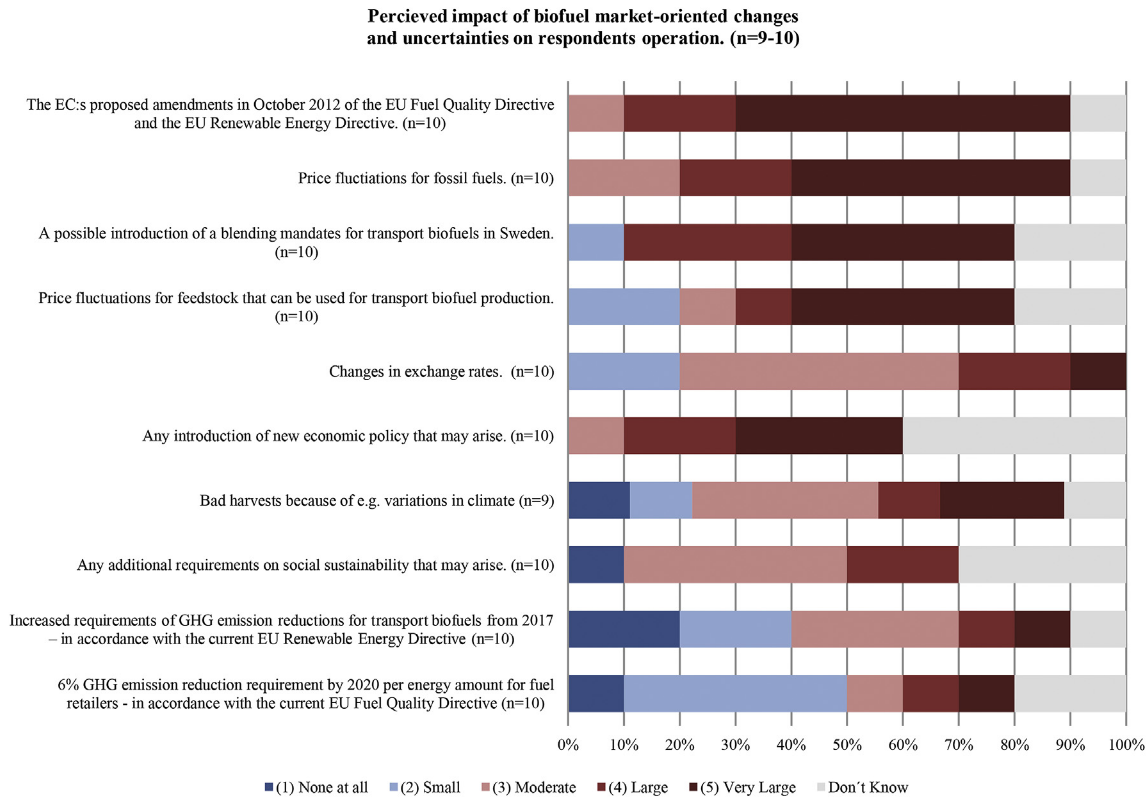

Fig. 3. Responses to the survey question: "The transport biofuel market is affected by several factors – such as existing legislation, upcoming policies, and interaction with other markets. How do you assess the impact of the following market-oriented changes and uncertainties on your operation?" (n = 10). Categories based on work of Stupak et al. (2012).

hand, commented that effects of requirements could be seen in that certain feedstock – such as feedstock from territories classified as 'NUTS 2' – could no longer be used for LTB production {P14}. Similarly, but regarding added costs, three of the respondents {P14, P34, P35} had experienced 'significant' costs associated with raw material costs increasing as a result of the new requirements.

Although both retailers and producers commented that the development of a verification system and procedures suited for their operation was costly and time consuming {R5, P35, R32}, and that legislation felt incomplete {R5}, all respondents were either 'satisfied' or 'very satisfied' with their chosen means of verification.

Statistics disclosed that firms delivering LTB in Sweden had to a larger extent complied with legislation through the Swedish national system by directly collaborating with their suppliers instead of certification organizations with voluntary schemes ratified by the EU. Given the flexible nature of the regulatory system, and that many of the respondents had worked with biofuel 'sustainability' prior to the introduction of the EU SC, it appears that the necessary technical know-how to codify information, and relationship with suppliers necessary to sustain transactions already existed among some of the largest retailers and producers. These firms had also delivered a broad set of different LTB, while also increasing the amounts of residue and waste-based LTB. Although no legislated incentive is provided to LTB that reduce GHG emissions beyond the threshold, this shift may serve a strategic purpose for them as they develop relationships with key suppliers of fuel and feedstock that can be used regardless of the pathway of EU policy development.

To relate findings to chain governance structures, responses were indicative of large retailers – seeking to secure a steady supply of LTB for further distribution – preferred a self-made system designed and tailored to their needs. Together with the levels of satisfaction among respondents (both retailers and producers), there seems to be a high capacity to abide to the transactional requirements introduced through the EU SC. For producers, this was further underlined in how many viewed certifying their LTB with voluntary schemes as a way to show buyers that they already abide to the rules of participation. This implies that, at least among the large retailers and producers responding to the survey, actors delivering LTB in Sweden mainly deal with modular type chain governance structures, where producers would not be as dependent on their buyers, while also being capable of more easily switching partners within the EU market.

However, evidence gathered in this study is insufficient to disclose how retailers coordinate their activities with LTB suppliers outside of the EU. That said, given the requirements (based on risk assessments) included in the regulatory system, and the perceptions held by several retailers regarding trust and a risk for falsified information, it appears that suppliers outside of the EU with low capacity to demonstrate compliance will find it difficult to gain entry to the market. Given the low tolerance of distance of captive chains (with low capabilities in the supply base) it is highly probable that most of the non-EU suppliers of LTB had significant organizational capacity to meet requirements, where empirics show that one pathway to do so was by providing biofuel certified with the ISCC (having no feedstock or regional restriction).

4.3.2. *Coordinating value chains among uncertainties*

With its many different feedstock types and global territorial configuration, retailers and producers of LTB in Sweden coordinate their economic activities as part of a global market that includes many uncertainties. We asked respondents to assess the impact of a

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set of market related, and a set of more explicitly policy related, changes and uncertainties on their operation.

In terms of legislative changes, the amendment proposed by EC in 2012, together with uncertainty surrounding the introduction of blending mandates for transport biofuels on a national level, were perceived as uncertainties that had a 'large' or 'very large' impact on their operation (see Fig. 3). However, stricter requirements for GHG emission reductions within the current legal framework were not considered as having a significant impact on their operation.

Statistics showed that with current calculation methods, canola-based FAME with an average GHG emission reduction of 40% (and corresponded to 35% of the total delivered energy amount of LTB in 2012) was present in the Swedish energy system. As such, the double-thrust of an already up-coming stricter GHG threshold together with the design of the ILUC-proposal directly affecting GHG calculations of LTB produced from oil-based crops seemed to be of big concern to respondents. Within the current framework, the average emission reductions for all non-FAME LTB were above future thresholds, and given the GHG performance of FAME had been slowly improving, this leans towards retailers and producers in Sweden being confident in their capacity to meet them in due time.

The October 2012 ILUC-proposal aside, the impact of price fluctuations for fossil fuels, closely followed by price fluctuations of feedstock, was also viewed as having at least a 'large' impact by half of the respondents that answered the question {P14, P34, P35, R12, R32}. Hence, the interplay between the LTB market and adjacent markets, such as fossil fuel and food markets, cannot be downplayed.

5. Concluding discussion

Examining the territorial configuration of LTB delivered in Sweden, this study provides strong evidence that the EU SC serves to regulate production beyond EU's territory. For the three year period covered by Swedish data, the material and spatial organization of supply chains do not appear to have been subjected to any (larger) disruptions. This provides evidence of a certain stability in the relationships between retailers, producers and suppliers within the LTB sector. A modest shift towards more residue-based LTB is interpreted to serve a strategic purpose as firms develop relationships with key suppliers of fuel and feedstock that can be used regardless of the medium term development of EU policy.

Shifting focus to regulatory systems, the means of compliance is found to differ between retailers and producers, which have predominantly modular and captive chain governance structures organized as networks within EU's flexible institutional framework. GVCs consist of numerous individual transactions, which are affected by various factors including the dynamics of adjacent markets. As such, the existence of a broad variety of chain governance structures without any clear cut and homogeneous characterization of how these large networks of production and consumption are organized is to be expected. The analysis does however show that EU's hybrid regulatory system serves a central role in defining the rules and conditions of value chain participation. This in turn indicates that it affects inter-firm trade in fuel and feedstock.

Regarding the manner in which economic actors view 'sustainability', this study indicates that the concept and the term is in essence viewed as a technical question. The key focus displayed by industrial actors was on the GHG emission reduction performance of fuels. This stated, we perceive that respondents were very cautious in their approach to questions about the issues associated with ILUC – which contains sustainability concerns connected with food security debated even before the genesis of EU's Renewable Energy Directive.

This work indicates that the certification of fuel with voluntary schemes is mainly a question for actors working on the supply-side that is driven by legislative requirements on the demand-side. However, this study found no evidence that retailers in Sweden will choose fuels certified with voluntary schemes to go beyond the mandatory minimum requirements in the absence of stricter regulation, or without further market incentives. Where producers outside of EU territory seek to gain entry to the EU market (where retailers are the gate-keepers) specific voluntary schemes seems to be the most likely means of meeting the rules of participation, however such endevours would require a large organizational capacity in the supplier base.

In conclusion, renewable energy targets for the transport sector acting with the hybrid regulatory system of the EU SC, do not serve in tangible ways to 'promote sustainability' as they are applied in Sweden today. Rather, this work shows that regulation serves to assure a degree of traceability of the economic activities of retailers and producers, and provides evidence that GHG thresholds included in the EU SC are met. It is important to note that these are based on the preferred calculation methods of retailers and producers, and do not include any ILUC considerations. Further, while this traceability allows civil-society to react on the basis of which countries supply feedstock for LTB, active responses from citizens to poor supply chain conditions remain difficult. This is exemplified by the time lag and aggregated nature of official reporting, and LTB mainly being consumed through low-admixtured diesel and ethanol blends. Hence, the low degree of transparency in the actual fuel supply chain further underlines that much of the power and responsibility for assuring the sustainability of large-scale LTB production is delegated to the economic actors. These actors however, have few incentives to go beyond the mandatory baseline requirements of EU regulation.

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Acronyms

EC	European Commission
EU	European Union
EU SC	European Union's sustainability criteria for bioliquids and transport biofuels
FAME	fatty acid methyl esters
GHG	greenhouse gas
GVC	global value chain
HVO	Hydrotreated vegetable oil
LTB	liquid transport biofuel
ILUC	in-direct land use change
ILO	International Labour Organization
ISCC	International Sustainability & Carbon Certification
NUTS	Nomenclature of Territorial Units for Statistics

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