Data Sharing Arrangements for Monitoring in the EU Circular Economy: The Case of CBAM and Steel Import for the EU Automotive Sector

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Abstract
The European Commission initiated a series of Directives and Regulations that aim to turn the linear economy into a climate-neutral and circular economy. Business-to-government information-sharing arrangements play an essential role in monitoring compliance with these regulatory measures. To this end data from the supply chain of products needs to be combined to create a full picture of the product life cycle. This requires the design of data-sharing arrangements in which businesses and governments share data.
The EU proposal to introduce the Carbon Border Adjustment Mechanism (CBAM) obliges EU importers and non-EU exporters to buy carbon certificates for goods imported into the EU Customs Union. Upon implementation, the CBAM will require monitoring activities by the EU Custom Authorities. We use the case of the import of steel for the EU automotive industry to explore the required data, scenarios for (voluntary) data sharing, and the role of (future) digital infrastructures for e-government. Our analysis shows that data sharing for compliance with the CBAM Regulation is relatively simple. However, if Customs Authorities need to go beyond the monitoring of single regulations, the situation becomes more complex. In addition, the diversity of data sources owned by a network of actors in different (future) digital infrastructures will increase.
Future research needs to go beyond data-sharing solutions for monitoring single regulations for circular economy towards combined data sharing for multiple regulations. This requires alignment between public and private interests to limit the administrative burden for businesses and government and an assessment of which digital infrastructures developed can be used to support data sharing.

Keywords: voluntary data sharing, circular economy, Customs Authorities, monitoring, steel, automotive sector, CBAM

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1 Introduction

With the adoption of the European Green Deal in 2019, the European Commission set an ambitious goal of creating a circular economy [1]. The publication was the starting point for a series of EU Directives and Regulations that aim at zero net emissions of greenhouse gases (GHG) by 2050, a sustainable and circular economy, and keeping valuable raw materials within the European Members States to diminish the dependence on import from beyond the EU [1]. In 2021 the European Commission proposed a Regulation that aims at the establishment of a carbon border adjustment mechanism (CBAM) [2]. The proposal was adopted on June 15th, 2021, and is currently in the discussion procedure before actual adoption. The aim of the proposed Regulation is the reduction of GHG emissions within EU Member States, while at the same time reducing the risk of so-called 'carbon leakage' which refers to the possibility that companies currently based in an EU Member State act strategically by moving their production to non-EU Member States to avoid paying for the GHG emissions from their production [2]. And to avoid that the products produced in the EU Member States were to be replaced by the import of GHG emissions-intensive products from non-EU Member States. Both strategies would undermine the aim of reducing GHG emissions globally.

Upon implementation, the CBAM regulation will have an impact on the activities of EU Customs Authorities. Their current tasks are primarily in the realm of safety & security checks of and revenue collection for goods entering the European Union (EU) [3], [4]. They will need to take on additional tasks for monitoring materials flows which require them to assess the data for monitoring cross-border flows, which stakeholders in a supply chain own the relevant data, and which data sharing infrastructures can support the (voluntary) sharing of business data from the source. In this article, the main research question is how to develop (voluntary) business-to-government (B2G) data-sharing arrangements to monitor compliance with the CBAM regulation. We use an inductive qualitative research approach for a case in the import of steel for the automotive sector, from the perspective of the Customs Authority in the Netherlands. In section 2 we present the theoretical background of our research and our research design in section 3. The analysis of the case is described in section 4. Subsequently, we present scenarios for (voluntary) B2G data sharing in section 5. In section 6 a critical reflection on the case is presented, and our conclusion and future research topics for data sharing in the context of the CE follow in section 7.

2 Theoretical background

In their 2021 article, Zeiss et al. call upon the information systems research community for developing intra-organizational digital solutions for the circular economy [5]. In this article we build upon the research on data-sharing arrangements for e-government: we use the concept of voluntary B2G data sharing for public value creation to explore potential data-sharing arrangements for cross-border monitoring [6]. The added value of voluntary data sharing for Customs Authorities was previously explored for cases such as the import of flowers [7], tires [4], and local food traceability [8]. The objective is to create a win-win situation in which businesses share their data for gaining benefits for smoother import procedures and the Customs Authorities gain in efficiency to execute their tasks for safety & security checks of and revenue collection for goods entering the EU [9]. To this end, access to data at the source (managed by the businesses) is a prerequisite. So far, these data mainly refer to batches of products and the logistics data along the supply chain [10], [11]. For CE monitoring, the data needs to be extended to include the materials composition of products from raw materials up and including data on the end-of-life stages where the materials are processed to be re-used for circularity [10], [12]. Additionally, the CBAM regulation requires data on the GHG emissions involved in the production of goods that cross EU borders [2]. In this article, we connect two hitherto relatively separated domains: the domain of data sources on the composition of products that can yield the required data for CE monitoring, and the e-government domain to explore the digital building blocks for B2G data sharing arrangements for compliance monitoring.

Life Cycle Analysis (LCA), report-based data provisioning, physical inspections, and chemical analysis are potential instruments to retrieve the required product details [13]. Potential data sources can be certificates, a digital product passport, Environmental Product Declarations, norms, and product specifications. These are based on industry-specific, cross-sectoral, and/or industry-independent data sources.

The e-government domain addresses information architectures through which B2G data-sharing arrangements can be executed. Over the past years, digital building blocks such as (commercial) digital platforms, extended data pipelines [14], blockchain-based architectures for end-to-end supply chain traceability [15], federated data models [16], digital product passports [17]–[19] and data spaces such as GAIA-X [20] have been initiated and developed. These digital infrastructures can support data sharing between businesses (B2B) and between businesses with governmental organizations (B2G). These building blocks are either initiated by governments for generic applications, or by the relevant sector itself for sector-specific applications such as e.g., the textiles, electronics, or automotive sector, or they are offered as data visibility solutions by commercial providers.

The diversity of relevant data sources and the rise of different potential information architectures complicates the choices to be made for the development of B2G data-sharing arrangements from the perspective of Customs Authorities. In this article, we illustrate how (voluntary) B2G data-sharing arrangements to monitor compliance with the CBAM regulation can be developed using a use case in the import of steel for the automotive industry.

3 Research approach and methods

Our research approach is in inductive qualitative research in which we analyze the case of steel for the automotive industry to explore the potential of digital building blocks for monitoring cross-border steel flows by the Dutch Customs Authority [2]. The case selection is based on the DATAPIPE project in which the Delft University of Technology and TNO collaborate with the Dutch Customs Administration and the Dutch Ministry of Infrastructure and Water Management. The project objective is to develop an extended data pipeline for compliance monitoring with data on the goods, logistics, material composition, production process, and data on reuse and recycling [21]. According to Cullen et al. "[o]ne quarter of all industrial CO_2 comes from steelmaking – equal to 9% of global CO_2 from energy and industrial processes- making steel's carbon footprint larger than any other industrial sector[23, p. 13048]. They estimate that 13% of steel is used for the manufacturing of cars [23, p. 1305, fig. 1, 2008 data]. Hence, the case represents a substantial source of CO_2 emissions in cross-border flows. Moreover, steel is a complex product that undergoes several processes from the stage of raw material, into different semi-finished products, to be used for or integrated into end products, which can be decomposed at the end-of-life cycle for reuse. This makes the monitoring for CE across these stages very complex. Therefore, we consider this case to be representative of the challenges that EU regulations entail on the activities of governmental organizations for monitoring circularity. In this article, we focus on the CBAM directive and its impact on compliance monitoring for the import of steel into the EU for the automotive industry, from the perspective of Dutch Customs.

In the period October 2022-March 2023, we gained empirical insights via engagements with the main stakeholders along the steel and automotive supply chains and we reviewed legislative documents, academic and grey literature on these supply chains, and the potential building blocks for voluntary B2G data sharing for compliance monitoring. In the next sections, we present which data (sources) are required for monitoring under the CBAM directive (section 4) and explore the potential digital building blocks for B2G data sharing (section 5).

4 Steel supply chain analysis

For setting the context we first present the steel supply chain for the automotive industry and the involved stakeholders that can share data for monitoring purposes. Next, we discuss the relevance of the CBAM regulation for steel import and the scenarios for CBAM monitoring by the Dutch Customs Authorities.

Steel supply chain and actors involved

Understanding the requirements for monitoring requires an analysis of the metal supply chain for the automotive industry, the relevant business actors involved, and the government involvement in the monitoring processes and the kind of information they require. We start with describing the metals value chain but zoom in on the steel supply chain, due to the large volumes of steel that are used in the automotive industry in the EU [22]. The life cycle of steel covers several phases, starting with the extraction of raw materials from the earth's reserves, toward the design and production of the steel into products. In the automotive industry, these are parts and components that are used in cars. Car manufacturers (OEMs) use steel plates and bars to construct car components. At the end-of-life of the vehicle, the car is dismantled, and the steel parts will be retrieved for recycling purposes by dismantling companies. This yields steel scrap of different qualities for reuse.

The provenance of iron ore marks the starting point of the metals value chain. Already at this point, data collection and utilization play a crucial role to establish a circular steel economy. From the perspective of the car manufacturers in the automotive industry, upstream data coherence is important to comply with reporting obligations towards a CE and pollution in the EU [23]–[25]. The miners hold the initial information on provenance, iron ore sourcing labour circumstances, and on environmental pollution/depletion. Most mining operations happen outside of the EU (16 billion USD imported iron ore versus 2.6 billion USD exported in 2021[26]).

When the ore is processed into steel outside of the EU, the steel is imported through middlemen and suppliers, where mostly steelmakers process it for the parts manufacturers and automotive suppliers. Steel production splits into primary and secondary production, in which the latter plays an important part on the road toward circularity [27]. Primary steel is produced in blast furnaces (BF) melting the iron ore and providing the desired state of the metal. This process is very energy-consuming as high temperatures need to be reached while substantial amounts of slag by-products arise.

Secondary steel production uses mainly scrap steel that has been extracted from, e.g., end-of-life vehicles. In this way, a circular steel flow can be established for which electric arc furnaces (EAF) are used that use less energy than the primary steel production and can be operated with renewable energy. However, due to the impurities in the scrap, the secondary steel is mainly downcycled. Current upcycling and purification mechanisms are too expensive or too energy-consuming [27].

Enhancing the circularity of secondary steel and lowering the emissions in steel production processes requires several changes.

First, the current incomplete data on the composition of secondary steel obstructs high-value recycling. Granular data about steel composition for recyclers and steel demand from the industry side is needed to ensure that usable secondary steel is recycled appropriately.

Second, metal processing technologies and steel production techniques emit higher amounts of carbon as coal-fired blast furnace (BF) processes are predominantly used compared to electric arc furnaces (EAF), also in the EU. Incentives to use electric energy for EAF secondary steel processing would support the sustainability efforts of the steel industry.

Third, following EU environmental Due Diligence regulations, in 2018 approximately 82% of the scrap from the Netherlands was exported to countries that have less stringent regulations on recycling processes, such as Turkey or China where mainly coal-fired BF are used [29]. In these countries, the EU monitoring loses its influence. This pollution imbalance is addressed by the CBAM regulation that also stimulates the use of EAF and locally processed steel in the EU. Through CBAM, energy-intensive sectors such as steel and energy itself will be regulated with taxes to be compliant with EU emission requirements.

CBAM and Customs Authorities monitoring for steel import

To limit, and over-time reduce the GHG emissions of the power and heat generation and energy-intensive industries within the EU, the cap-and-trade system for specific emissions was designed: the EU Emission Trading System (EU ETS) [28]. The ETS system should cost-effectively reduce CO2, N_2O, and PFC emissions. Intensive industries need to buy carbon credits to offset their emissions and the number of available credits is reduced yearly. A risk of the EU ETS legislation is that companies move their operations to regions with less stringent emissions regulation, a phenomenon known as 'carbon leakage'. To ensure a level playing field between EU and non-EU businesses, the CBAM has been designed. In its first phase of application, CBAM will be applied to the import of cement, iron, steel, aluminum, fertilizers, electricity, and hydrogen. These sectors were selected due to the high risk of carbon leakage, and the number of sectors was limited for administrative simplicity.

CBAM will affect steel imported into the EU and enforce businesses to report the direct CO_2 emissions emitted during its production. CBAM addresses special product code categories, called Harmonized Systems (HS) codes, to indicate the steel products that will be monitored. These HS codes are key for monitoring the cross-border movement of goods, as per HS code it is defined which procedures the Customs Authorities need to follow in terms of fiscal, and other controls [29]. Examples of HS codes for steel products relevant to CBAM are:

1. HS code 7303 00 for Tubes, pipes, and hollow profiles, of cast iron, or
2. HS code 7308 for Structures and parts of structures of iron or steel; plates, rods, angles, shapes, sections, tubes, and the like, prepared for use in structures, of iron or steel [32].

Not all imported steel and iron will be covered by CBAM. If the material is applied within a product, e.g., steel within an imported car, the emissions are not covered by CBAM. All steel and iron products for which the CBAM will be applicable are specified in the legislation [32, Annex I].

The envisaged customs procedure for CBAM is as follows [30]. The EU importer of goods covered by CBAM needs to be registered with national authorities in an EU Member State where they can buy CBAM certificates, which are based on weekly ETS allowances. The EU importer declares the emissions embedded in the imports and surrenders the corresponding number of certificates each year. If the importer can prove that a carbon price has already been paid during the production of the imported goods, the corresponding number of certificates can be deducted.

Scenarios for CBAM monitoring of steel import in the EU

We distinguish three scenarios for data-sharing arrangements between the steel importer and the EU National Customs Authority:

- Scenario 1: When the importer does not have information about the production process in the country of production then industry emission averages can be applied. If these industry averages are favorable, businesses may not need to make efforts in providing more accurate information. In this case, there will be no need to use additional digital infrastructures to share additional data.
- Scenario 2: If the industry emission averages are disadvantageous for the importer, they may need to pay higher taxes compared to sharing information based on their supply chain data. This may be an incentive for companies to obtain data about the emissions from the exporting country. In this scenario, the importer will need to have access to data on the emissions generated abroad and will need to share these data with the Customs Authority.
- Scenario 3: When businesses pay taxes for emissions in the country of production, the importer does not need to pay them again in the EU. In this scenario, the importer needs to share the relevant emissions data and also needs to provide proof that the emissions have been paid in the country of origin.

Scenarios 2 and 3 refer to voluntary data sharing between steel importers and the EU Customs Authority to avoid paying too much for their imports. In the next section, we address the digital building blocks that can be selected by EU Customs Authorities to monitor compliance with the CBAM regulations.

5 Digital building blocks for CE monitoring

The CBAM directive (and other regulations aimed at circularity and sustainability) requires the Dutch Customs Authorities to add a new strand of monitoring to their current tasks which are primarily in the realm of safety & security checks of and revenue collection for goods entering the European Union (EU) [3], [4]. They will need to take on additional tasks for monitoring cross-border materials flows which require access to new types of data. In the three scenarios for monitoring compliance with the CBAM directive, as presented in the previous section, a mix of mandatory and voluntary data sharing can be applied to this end. In this section, we explore options for digital building blocks that can be used for this monitoring process.

Data-sharing solutions for cross-validation

In scenarios 2 and 3 the Customs Authority needs to cross-validate the data about emissions and about whether emissions have already been paid in the country of origin. Asking for additional documents to obtain sufficient proof may unwantedly increase administrative burdens for companies. Instead, it can be useful to look at the potential of voluntary data sharing: whether using digital infrastructures companies can provide such additional data for cross-validation purposes. Similar cases for voluntary data sharing have been piloted in the past for fiscal and security purposes [4], [6] and seem promising to be applied to emissions monitoring as well.

However, in these previous studies, additional data was used for monitoring specific transactions. In contrast, the reporting and monitoring in the CBAM case are done once per year only, rather than per specific transaction each time a steel shipment enters the EU. In addition, although getting data from the source company to cross-validate the emissions declarations may be useful, it may also be achieved by sharing aggregate data from the source (e.g., the steel producer in China). This can be done on a yearly basis using simple exchange protocols with the Dutch Customs Authority. Whether and how this will be needed depends on how the CBAM legislation is implemented.

Data sharing via industry visibility solutions

At the same time, looking beyond CBAM into the wider circularity and sustainability field, we see that companies and supply chains are investing in visibility solutions. These investments are driven by their business drivers for regaining materials for recycling, driven by a range of (future) legislations related to circularity and sustainability which they need to comply with, or driven by consumer demands for transparency on product-related information. This trend leads to the rise of digital infrastructures which potentially hold a great deal of data that can be used by governments for circularity and sustainability monitoring. Through these digital infrastructures, governments can tap into data such as Environmental Product Declaration data (EPD: a third-party verified document with data on the environmental impact of a product). Whether or not governments can tap into such potentially available data depends on several issues.

First, whether there are incentives for businesses and governments to invest in data sharing solutions and voluntary data sharing. In our current stand-alone CBAM case, the incentives for investing in infrastructures for data-sharing may be limited, but these incentives may change when taking a broader set of legislative obligations into account. Examples are the Waste Shipment Directive to combat the export of valuable raw materials [31], the Batteries regulation [32] but also the introduction of Digital Product Passports [18], [33].

Second, depending on how far governments need to gain access to reliable information, they may need to access data not only of the producer but also of the raw materials supplier (be it of primary or secondary materials). This data will reside in different platforms, either sector-specific or related to a specific production phase along the materials life cycle. For the businesses this will lead to complexity in sharing their data with a diversity of stakeholders, for which incentive alignment is needed. For governments, this will require access to data that resides in multiple digital platforms and a challenge to align incentives with businesses for data-sharing for public value creation.

Third, governments do not monitor single companies or single supply chains, they are monitoring many companies and many different supply chains. For those supply chains that are interested in sharing additional voluntary data, governments would need to have a way to interface with these different platforms and solutions and to have a uniform way of connecting to them. This requires data harmonization and interoperability. The development of data ontologies and upper-level ontologies can be instrumental to reach the required data harmonization along the circular supply chains [34].

Data sharing via EU-initiated solutions

At the EU level, a myriad of technical data-sharing solutions is currently developed, such as international data spaces and their related data ontologies, GAIA-X for a European cloud architecture, blockchain architectures developed at the EU level (e.g., EBSI), and the creation of digital product passports. These will all play an important role in the decision-making process of businesses on why (not) to share additional business data with governments and which investments need to be considered (both by businesses and governments) if they opt for developing (voluntary) data sharing solutions.

Data sharing via international collaborations

In addition to the presented technical data-sharing options, the question of which parties next to the Dutch Customs Authorities can play a role needs to be answered. For example, the ETS monitors the emissions of companies in the EU. If similar systems are installed in regions with big trade volumes, then exchanging information between countries is an alternative way to monitor the emissions. This route requires international collaborations between governments and entails implications on the digital infrastructures or interfaces that need to be developed for international data exchanges.

6 Critical Reflection

In this article, we connect two hitherto relatively separated domains. The domain of data sources on the composition of products can yield the required data for CE monitoring. And the e-government domain to explore the digital building blocks for B2G data-sharing arrangements for compliance monitoring. In this section, we offer a critical reflection on this connection that is characterized by uncertainties in the development of B2G data-sharing arrangements

The CBAM legislation sets a first step to create a level playing field for industries that are part of the EU ETS. However, the scope of the included emissions for the CBAM is rather limited since only the direct CO_2 emissions from the production process of the imported products are included [2]. In other words: only the emissions from the material processing in the steel factory are included, see Figure 1[35].

CO_2 emissions emitted down the value chain are not yet included for steel products, such as emissions from supplied materials and energy delivered to the factory. Downstream emissions of EU ETS sectors that are emitted within the EU are indirectly covered since they must comply with legislation themselves. Therefore, quite a few more emissions are covered by the EU ETS compared to the CBAM when the product is produced within the EU versus outside the EU, see the example of steel in Figure 2. Due to this competitive disadvantage on the product level for EU steel producers, an extension of the scope is considered but will not happen before the revision of the CBAM in 2026.

Looking at the data and data reporting, CBAM concerns only a limited number of goods, e.g., steel, and cement, it focuses only on CO_2 emissions and the reporting is on an annual basis, and industry averages will be applied if more accurate information from the supply chain is missing. Thus, data collected under the CBAM legislation will only create new insights into a limited, specific scope if the suppliers can provide relevant information to the Customs Authorities.

For the EU ETS, the emissions are registered at a company level and, thus, are not allocated to the specific products produced. Since the CBAM is only about the imported goods, and not all CO_2 emissions of a company, they need to be allocated over the various products produced. This implies that product-specific information needs to be available, just as is the case for information from the Environmental Product Declarations and similar emission-allocation guidelines need to be applied [37].

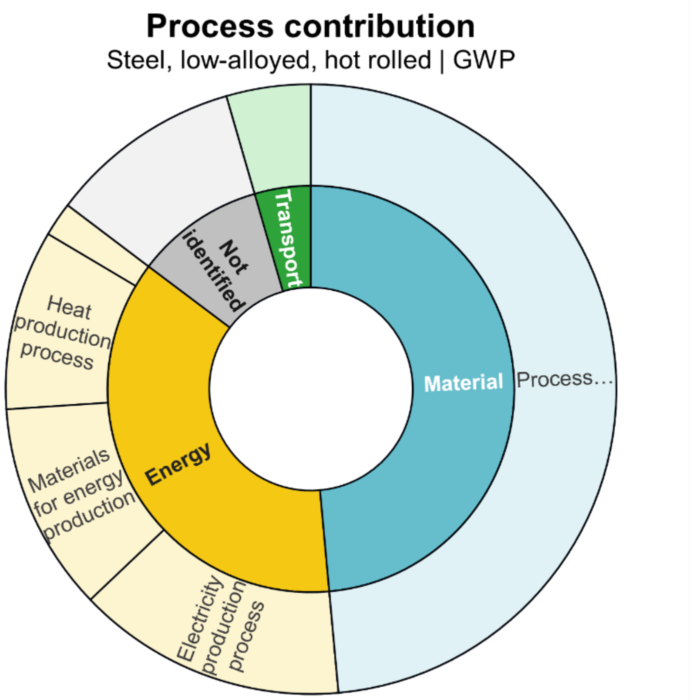

Figure 1 Process contribution (cut-off 0,1%) for the global warming potential (in CO2 eq.) of low-alloyed hot rolled steel global industrial average assessed from EcoInvent v3.9 [36]

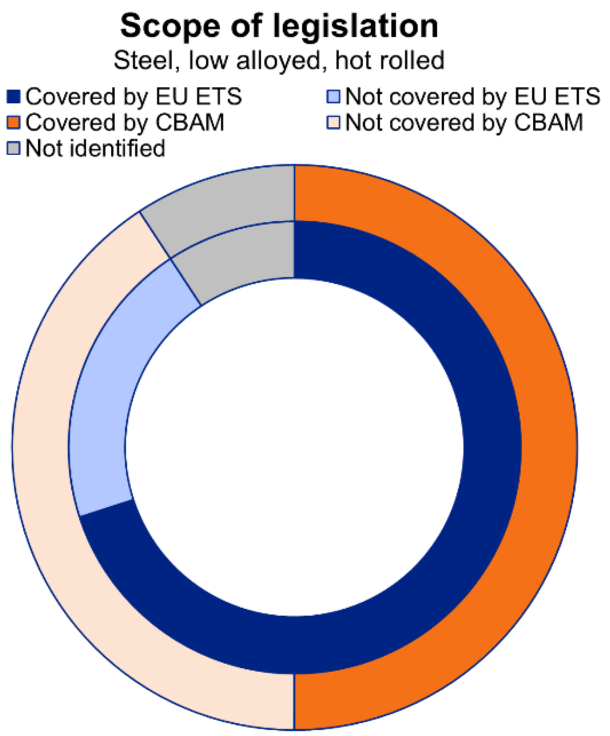

Figure 2 Scope of legislation for CO2 emissions (based on CO2 eq. emissions) of low-alloyed hot rolled steel global industrial average assessed from EcoInvent v3.9 [36]

Reflecting on the comprehensiveness of CBAM information, it is quite limited compared to information that can be extracted from EPD data. In an EPD more types of emissions and downstream emissions are included which creates significantly different results, as can be retrieved from Figure 2 for the emissions of a steel-EPD that are covered by the different legislations [35]. EPD data is still created on a voluntary base, limited available due to the complexity, and goes along with different perspectives on the calculation guidelines. But EPD data may be of interest when CBAM is extended in the future to include more emission types related to steel production and import.

This expansion of data sources will lead to more data for the monitoring tasks of the Customs Authorities. In addition, more EU regulations targeted at circularity and sustainability will require more monitoring for which data sources and data-sharing arrangements need to be created. Thus, the selection of which digital building blocks can be used for their monitoring tasks becomes even more challenging. Therefore, topics like the limitation of the administrative burden, the required granularity of the data, which actors in the supply chains and which governmental organizations to collaborate with, and which incentives to create (voluntary) data-sharing arrangements for public value creation, will be high on the agenda of all stakeholders involved.

7 Conclusion

Current and future EU legislation intends to stimulate industries and society toward more circular and sustainable practices. Monitoring this development not only requires the determination of the data but also the choice of digital infrastructures that can play a role in (voluntary) B2G information-sharing arrangements.

In this article, the main research question was how to develop (voluntary) B2G information-sharing arrangements for compliance with the CBAM regulation. We presented the data that Dutch Customs Authorities will need to monitor for compliance, which stakeholders in a supply chain own the relevant data, and which digital building blocks can support the voluntary sharing of business data. To illustrate the complexity, we used the case of the import of steel for the automotive sector into the EU, taking the perspective of the Dutch Customs Authority. Under the proposed CBAM regulation EU steel importers can choose from 3 scenarios for the required reporting of the CO_2 emissions generated by the steel production in non-EU countries to the Dutch Customs Authority. In two scenarios they may have incentives to voluntarily share business data to lower their costs for compliance with the CBAM regulation.

Future extensions to the CBAM regulation can add other data requirements. In addition, other EU regulations for establishing a CE will lead to an extension of the monitoring activities of the Customs Authorities. This raises the question of how to limit the administrative burden on businesses and governments by using data that is already available in digital infrastructures along the supply chains. Several parallel initiatives can facilitate access to these data such as the growth in supply chain visibility solutions, increased digitization of supply chains, and the emergence of international data spaces, Gaia-X for a European cloud architecture, and public and private blockchain architectures.

In our future research we will focus on the analysis of EU regulations for the CE, the ensuing data (sharing) requirements, incentives for businesses to voluntarily share data with Customs Authorities, and the digital architectures that contain the relevant data. The main research question in this article on how a data-sharing solution can be created by aligning the building blocks for the required data (sources), the data-sharing architecture, and the stakeholders involved will be applied to other materials within the automotive sector such as batteries and electronics that are subject to the EU regulatory framework for the transition towards a CE.

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