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Identifying fraud through mass balancing – is it possible?

A study of a mixed method approach in the Norwegian fishing industry

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Summary/recommendation:

In this report, we have used a mixed-method approach comprised of a mass balancing combined with a mapping of the regulatory framework and an in-depth case study to highlight sources of discrepancies in the supply chain in the Norwegian whitefish industry. Mass balancing reveals a discrepancy between input and output of cod. Mass balancing is performed using publicly available data on landings, consumption and trade. In an attempt to explain the discrepancy, different sources of errors are identified by analysing the regulatory framework and the context.

Three sources of main errors are identified and discussed: errors in source data, errors in the method of mass balancing (Material Flow Analysis) and fraud. There are two information gaps in the public records in Norway: a lack of specific product registration in the production phase and actual figures on inland consumption which are provided as estimation only. Furthermore, conversion factors are used to generate a common denominator when balancing numbers for both landings and export. These factors stand out as important sources of error that should be investigated in more detail. Warehousing also appears to influence this discrepancy, especially in periods with market challenges.

The approach is useful for identifying discrepancies and anomalies but does not detect fraud as such. It should be used as a supplement to other methods rather than as a stand-alone tool.

Summary/recommendation in Norwegian:

For å belyse avviket som oppstår mellom landinger, konsum og handel av torsk, har vi kombinert en sammenstillingsanalyse med en studie av regelverk og et dybdeintervju med en bedrift. Feil i datakilder, feil i metoden som benyttes ved sammenstillingen samt ulovligheter er mulige årsaker til avviket avdekkes. Tilnærmingen er nyttig for å identifisere feilkilder og uregelmessigheter, men den tallfester ikke et eventuelt ulovlig fiske. Det trengs mer detaljert informasjon om hvor mye ulike feilkilder, som omregningsfaktorer og lagerhold, faktisk påvirker analysen. Informasjonshull som mangel på en registrering av faktisk anvendelse i landingsstatikken og ingen offentlig registrering av innenlands konsum, bør tettes for å få en bedre analyse.

Preface

This work was undertaken through the project FoodIntegrity. FoodIntegrity has received funding from the European Union's Seventh Framework Programme for Research, Technological Development and Demonstration under Grant Agreement No. 613688.

We wish to thank the Directorate of Fisheries, Norwegian Customs and the Norwegian Food Safety Authority for quality checking our mapping of the public records under these authorities. A special thanks to the company in the case study which provided us with useful information and contextual knowledge on recordkeeping in the Norwegian whitefish industry.

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1 Global food supply chain complexity

Through globalisation, food production has become a global venture. With easier modes of travel and improved logistics, as well as increased purchasing power among consumers worldwide, foodstuffs previously regarded as exotic are now much more readily available. This change has led, among other things, to improved market opportunities for producers as well as more diverse dietary options for consumers. However, the development of the global food supply chain has also brought with it an increased complexity. With food production no longer confined on a geographical scale, the number of nodes in the supply chain has increased and, with it, the potential for unlawful activity.

Food fraud is an issue that affects a wide variety of products in many different sectors. Examples include fish and other seafood products, herbs and spices, and plant-based foods such as olive oil. Fraud can occur in numerous ways at any point in the supply chain and varies in scope and severity. Different ways to commit fraud include, but are not limited to, adding or substituting components, counterfeiting product packaging, and transferring products through different countries (Spink & Moyer, 2011). In the context of the fisheries, examples of fraud include catches not being registered on landing, and species being intentionally declared as a different species. Fraud is most often economically motivated but can also be motivated by the intention to commit harm, thus representing a potential health hazard as well as an economical issue (ibid). Fraud is thus a highly multi-layered issue that reverberates throughout the supply chain, regardless of sector or commodity.

Despite being tightly regulated with many registration requirements and control points, the Norwegian fishing industry has seen several confirmed cases of criminal activity (Christophersen, 2011). Although no exact figures are available, a study in 2013 estimated the scope of fraud in the cod sector to be around 5% of the total catch (Svorken & Hermansen, 2014). Attempts to balance imports and landings with domestic consumption and exports have been made, and have shown that a gap does exist (NRK, 2017; Fiskeribladet, 2018; Norsk Fiskerinæring, 2018). While it is likely that trade of illegal, unreported and unregulated (IUU) fish can explain some of the gap, the production process is highly complex, with many factors potentially contributing to a discrepancy. A discrepancy can occur for a variety of reasons including as a result of production process errors, poor control in the supply chain, a complex regulatory framework, human error, etc. further complicating the matter. This added complexity puts additional pressure on the control functions set up to ensure the integrity of the supply chain.

Using the Norwegian cod industry as an example, we attempt to develop a model aimed at mapping the flow of goods in the Norwegian fishery sector, based on public registrations made in the supply chain. We further attempt to identify weaknesses in the regulatory system that could affect the accuracy of the model. We utilize a mixed-method approach, drawing on both qualitative and quantitative methods (Creswell & Plano Clark, 5:2006). First, we perform a material flow analysis, in which we attempt to balance landings and imports of cod with domestic consumption and exports. This is supplemented with an analysis of the regulatory framework governing product registrations in the Norwegian cod fishery, and interviews with a production company.

The structure of the report is as follows: first, we present the results from the material flow analysis, the regulatory framework analysis and the case study. We then discuss possible implications for the study of food supply chains, and the potential of the model and the mixed-method approach presented here. Lastly, we present possible avenues for further research based on this approach.

2 Material flow balance of cod in Norway

This chapter presents the material flow balance of cod in Norway. The purpose of the analysis is to investigate whether it is possible by studying publicly available data to follow the flow of cod landed in Norway from the harbour to Norwegian or international customers. We attempt to balance the volume going into the Norwegian system via landings and imports, with the volume leaving the system via consumption and trade. The data included in the balance are both mandatory registrations collected by authorities, as well as generalized estimates based on voluntary self-reporting. The analysis can be performed on all registrations that enable us to identify a smaller group and connect it to a specific volume.

The analysis is based on the theory of Material Flow Analysis, more commonly referred to as MFA, and two well-established principles, the systems approach and the mass balance principle. MFA is a methodology developed to assess the flows and stocks of goods and materials within a set time and space (Brunner & Rechberger, 2004). The foundation of this study is the mass balance principle, which explains that matter is conserved in any system, and thus input is equal to output mass. The systems approach considers the attributes of an entire system, and thus examines how the goods, material and substances interact with the environment, for example through waste production and emissions. Due to resource and scope limitations, we have to a lesser degree considered the systems approach in our analysis. However, because we need to include waste production to balance input against output, this analysis uses conversion factors to estimate the whole, live fish equivalent of a cod product in the grocery store.

2.1 Definitions of the system

Material flow studies require a clear understanding of the system boundary, the processes included in the system, the material flow between processes, and the stocks and materials within the process (Brunner & Rechberger, 2004). *The system under investigation* is Norway, and the *main processes* in the system is the production of fish products such as salting, freezing, filleting, etc. The production process is accounted for using conversion factors and not the actual data for waste and by-products. Other processes in the system include harvesting in the Norwegian exclusive economic zone (EZZ) by Norwegian vessels, landing at Norwegian harbours, storage, and transport of whole or processed cod to national customers or to other economies. Processing occurs at many stages in the supply chain, with primary processing such as gutting often being done before landing the fish. The national customers are retail stores, hotels, restaurants, catering firms, while the international customers are outside of our system.

The exchange between the system and its environment occurs through landings of cod by foreign vessels at Norwegian harbours, and through import or export of finished cod products from and to other economies. Other flows, such as tourist fishing or fishing for private consumption are excluded from the mass balance. Fish caught and landed by foreign vessels with the purpose of being transited through Norway is also excluded.

Another concept that we should define clearly is the *stocks and materials* within the process. This study will focus on balancing the cod species overall as previously performed in other studies (Henriksen, 2013; Norsk Fiskerinæring 2018), as well as splitting the total cod category into three subcategories; fish processed into fresh, frozen or traditional products. The product categories were split into the

aforementioned categories due to differences in storage times. After specifying these definitions, we need to consider the temporal scale and the indicator element of the system. In order to limit the scope, t*he temporal scale* chosen for this study was per annum from 2010 to 2017. However, the analysis would also be interesting to perform on shorter intervals, per month for example. *The indicator element* is the physical entity that is measured, which in our case is weight and more specifically, live weight, of cod in tons.

2.2 Data sources

The mass balance is performed using data on landings, import, export, Norwegian consumption and conversion factors. Statistics on landings are extracted from a Nofima database containing registrations from *the sales note*. The sales note is a mandatory sales contract between the fisher and the buyer, and contains information on the fishing vessel, flag state, species caught, product descriptions, catch areas, etc. The landing data are extracted as live weight and are limited to landings of cod by Norwegian vessels in Norway. One important aspect to keep in mind is that many people and organizations (The Fishermen's Sales Organisations, Directorate of Fisheries and Nofima) are involved in processing the data, and we have noted that there are discrepancies between datasets.

Statistics on import and export of cod products were sent to us from the Norwegian Seafood Council upon request. The import statistics in this study largely consist of landings by foreign vessels in Norway – if the product is not in transit. The export statistics include all products that are exported from Norway, both of Norwegian or foreign origin. Both the import and export statistics are stated in product weight.

The exporters and importers are required by law to declare the product's statistical value (and other details) to Norwegian Customs . This declared value, among other things, forms the basis for calculating the export tax on fishery and aquaculture products. Because the declarations can be based on the company's own claim about the product properties, and not necessarily an actual new weighing of the products, incorrect information can intentionally and/or unintentionally find its way into the Trade Statistics. Random spot checks are carried out to deter companies from intentionally stating incorrect information on the declarations.

There are no mandatory registrations that measure the Norwegian consumption of cod. The consumption estimates used in this analysis are based on customer panel data collected by Growth From Knowledge (GfK) measuring household consumption, and the volume of cod products purchased by HoReCa (hotels, restaurants and catering) in Norway collected by Flesland Market Information. The consumption statistics are from The Norwegian Seafood Council's online database (Market Insight, 2018) and are stated in product weight. Note that the report for the years 2010 to 2012 estimated HoReCa consumption because the source contains a limited number of years.

The conversion factors used to convert products to whole live fish are from Nofima and the Directorate of Fisheries.

2.3 Method

The first step of the analysis is to convert the data from product weight to live weight in order to compare equivalent measurements. The second step is to classify the data according to the lowest common denominator in the dataset, which in this study is the product categories (fresh, frozen, traditional). The third and last step is to balance the data per year, species and at the lowest level, per product categories. The most important source-specific choices made in this analysis are discussed briefly below.

The landing statistics are stated in live weight and no conversion is needed. However, the accuracy of the conversion factors used in calculating these figures is currently under discussion (The Directorate of Fisheries, 2016). In order to calculate how the variation in conversion factors affect the balance, we have performed a simple sensitivity analysis by converting live weight to product weight using official conversion factors. Note that we assume that the official conversion factors are used correctly when reporting the data in the sales note.

The classification of landing statistics is performed using a registration called *assumed usage*. Assumed usage describes which production the fish is expected to be used for (fresh, salting, freezing, etc.), and not the actual usage. The reason for using this registration is because no registration describes the actual usage. An alternative way to split the data would be to use the *conservation* and *state* registrations, describing the state of the fish. However, this registration provides even less information on the production process, and would create a larger discrepancy in the balance.

Trade statistics, i.e. import and export statistics to and from Norway are converted per commodity code. Conversions based on trade data are based on the factors used in a previous Nofima project (Henriksen, 2013). In cases of new commodity codes, the most suitable conversion factors are used. By-products (e.g. *Cod, fresh edible by-products* and *Cod, stockfish, heads*) are removed from the analysis to prevent multiple conversion of the product to a whole live cod, as a whole fish can produce more than one product. The model also allows the conversion factors to vary enabling the effect on the balance to be examined; at the time of publishing this report we have no reason to suspect large errors in the trade conversion factors. Lastly, the classification is done based on the commodity code and title.

The domestic consumption estimates consist of two different sources, one attempting to measure household consumption and the other measuring the volume of cod products purchased by HoReCa. Together, these sources should provide us with an estimate of the total cod consumption in Norway. Both sources are naturally stated in product weight and must be converted. The household consumption is converted per product label using Nofima's latest conversion factors (Karlsen & Bendiksen, 2018). Products that cannot be classified according to the three product categories, as canned products (represent only 1 percent of the total consumption), are excluded from the analysis.

The HoReCa numbers are presented as highly aggregated product groups, e.g. *fresh whole*, *cod, salted/smoked/marinated frozen* or *clipfish/stockfish fresh*. Thus, in some instances the aggregates may include other whitefish species. The product groups are converted using the best-suited consumption conversion factors for the aggregated category (see Appendix 2 – HoReCa Conversion Factors). Note that the aggregated categories make it far more challenging to estimate correct volumes in live weight. Similar to the trade statistics, the model allows us to vary the conversion factors for both

sources to illustrate the effect on the result. The variation is not presented in the next chapter as we have no reason to suspect large errors in the dataset at the time of publishing this report. However, since the consumption figures are estimates and not mandatory registrations, the result is presented with a scenario containing no consumption/estimates (see Table 2.1). All HoReCa estimates are classified according to the three product groups.

After converting and classifying the different sources and datasets, the product groups and the total cod category are balanced according to the following assumption:

Input of cod	=	*output of cod*
Landings + import	=	*export + domestic consumption*

As previously mentioned, balancing is performed per year. The model allows us to model many different scenarios based on new information on the data sources, conversion factors, etc.

2.4 Results at species and product level

The mass balancing of cod shows that there is a discrepancy between input and output of cod in the Norwegian fisheries (Figure 2.1). If we measure the total accumulated discrepancy by subtracting output from input and dividing the result by the input, we find a discrepancy of -5% over the whole period. The negative sign indicates that output is higher than input when the years are summated, meaning more is consumed/exported than produced/imported. However, the average discrepancy is strongly influenced by 2010 and 2014 when discrepancy peaks at -23% and -9% (Table 2.1). In the other years, the discrepancy varies from 0% to -4%. The weighted average for all years excluding 2010 and 2014 is -2%.

Table 2.1 Discrepancies in the mass balance of cod with and without consumption estimates

	Normal	No consumption scenario
2010	-23%	-13%
2011	-4%	5%
2012	0%	9%
2013	-3%	4%
2014	-9%	-2%
2015	-3%	6%
2016	-3%	6%
2017	-2%	5%
Mean	-5%	3%

In Figure 2.2, the datasets are split into a lower level, i.e. fresh, traditional and frozen products. The result shows a larger average discrepancy in all product groups for all years: 24% in fresh, -26% in traditional and -8% in frozen products. In other words, less fresh products and more traditional and frozen products are on average produced and sold to customers than anticipated prior to production.

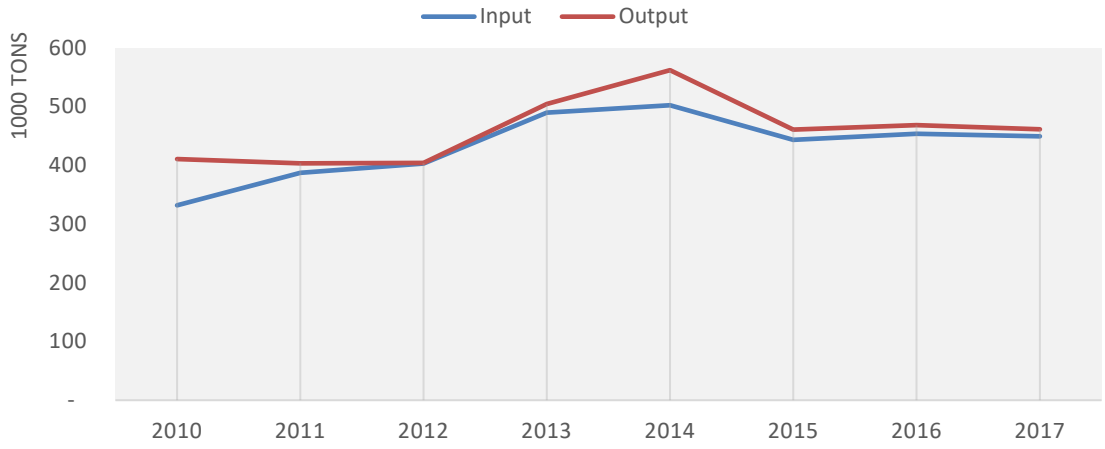

Figure 2.1 Total input and output of cod in Norway in the period 2010 to 2017

Figure 2.2 Input and output of cod in Norway per product in the period 2010-2017.

If we only include the mandatory registrations in the analysis, and thus exclude the domestic consumption estimates, output will equal export. In this scenario, the average discrepancy is 3% (Table 2.1). The positive average discrepancy is not surprising considering domestic consumption is omitted in this comparison, as one can expect that at least parts of the cod volume are sold on the Norwegian market. Despite excluding domestic consumption, 2010 and 2014 still have a negative discrepancy of -13% and -2% respectively.

Summarized, the method of mass balancing for input and output of cod based on the available data appears reasonable for acquiring an impression of the discrepancy level. Breaking it down to product level poses more challenges as there is an information gap in production that obviously affects the results.

The material flow analysis assumes that the data in the model are reliable. However, this is not necessarily the case. The seafood supply chain is highly complex, as is the production process, and this complexity might influence the veracity of the data and thus the model itself. In the following, we attempt to identify possible sources of errors caused by weakness in the regulatory framework governing product registrations, as well as aspects of the production process that could influence the model.

3 Regulatory framework analysis

The following section investigates the cod supply chain within the Norwegian borders and presents the results of the study on the legal framework pertaining to product registrations. As well as studying the relevant regulations, we also review previous studies pertaining to both monitoring and control in the fishery supply chain.

A description of the supply chain is given, along with an overview of the different regulatory requirements for each step and the main authorities. Because we are focussing on activities within the Norwegian border, registrations conducted by international organizations and businesses are excluded in our study. The supply chain is studied in relation to the public mandatory registrations collected from the industry actors by the national control authorities. However, in parts of the chain where information collection is lacking, alternative sources of information are explored. These include registrations collected for knowledge gathering and forecasting purposes instead of monitoring and control functions.

The entire chain for wild caught fish traditionally goes all the way from oceans to hands, chopsticks and forks. The supply chain has been divided into six stages: harvesting, landing, processing, sale, transport, and customer (Table 3.1).

Table 3.1 Stages of the supply chain for wild caught cod

Harvesting	The cod is caught at sea. Some processing may occur on board the vessel.
Landing	The fish is shipped to a port/post-harvest plant. The transaction between the vessel, plant and the producers usually occurs at this stage.
Production	The main transformation from a whole round fish to a product. For example: filet, saltfish, stockfish and clipfish production.
Sale	Business-to-business transaction from processing company and/or sales company to domestic sales channels or importers.
Transport	Transport of the product to a sales channel or importer (export).
Customer	The product has reached the customer. This includes the domestic seafood market or an international importer. Note that all registrations that are outside the Norwegian borders are excluded from this study.

3.1.1 Registration requirements and information collection

The fishing industry is subject to a plethora of registration requirements overseen by numerous authorities. Central among those gathering activity data are the Directorate of Fisheries, the Norwegian Food Safety Authority, Norwegian Customs and Norwegian Tax Administration. The aforementioned bodies mainly compile data related to the processing process and the movement of products along the supply chain, though their focus differs. All perform control functions as well as having the formal authority to implement sanctions in case of non-compliance (for more information, see Appendix 1 – Main authorities involved in controlling the cod supply chain).

Several other bodies also compile information on the industry, not for control purposes but for statistical analysis. The main beneficiaries of data here are Statistics Norway and the Norwegian Seafood Council. In addition to those collecting data concerning the product and production process, other bodies such as the county municipalities and the Labour Inspection Authority collect information

and carry out inspections on issues such as health and safety procedures related to labour conditions. The latter group will not be in focus here, as they do not deal with product-specific registrations.

No single authority has a complete overview of the cod supply chain. There is no overarching system common to the various authorities that is focused on monitoring and controlling food fraud or food integrity. As previously noted by Ekerhovd, Nøstbakken & Skjeret (2015), while the various relevant bodies do cooperate, there is no automatic system for sharing data between them.

There are also substantial differences in how information is collected, recorded, and aggregated by government bodies. The frequency of data collection varies (e.g. continuous, hourly, weekly, monthly, yearly), as does the requirements for data submission. Some require the operator to record the required information for inspections without specifying further delineation; some require enclosed documents when transporting products; and others require a specific technology for automatic transfer of information. Lastly, the information collected may be either publicly available or exempt from the public. The information is often published as non-identifiable and aggregated data.

3.1.2 Mapping registrations

The various registrations identified as pertaining to product information cover a wide array of topics, and can be grouped in four categories:

Table 3.2 Grouping registrations

Geographic origin/location	Indicators describing product origin, i.e. catch area and landing/production location. Catch area is recorded at the lowest level with both geographical coordinates indicating the vessels movements, as well as the FAO Major Fishing Area number of the region in question.
Time/Date	Recordings of the time and date of a product's movement along the supply chain include the date of catch, landing, and production, date of first-hand sale, as well as the time of transport and export.
Identification of food business operator	Recordings pertaining to the identification of an operator involved in the production, transport, or sale of foodstuffs at a given point in the supply chain. These include vessel owners, producers, senders/receivers, and transporters. The exact recordings vary depending on the given point in the chain and the type of operator in question, but most often include the name of the business and/or owner, address or a unique identifier (UID) such as an organisation number, vessel ID or similar.
Product properties	Registrations providing information on a product's weight, species, product condition, and conservation method. These are the records required most often throughout the supply chain and are essential in product identification and control. They can change during production, and earlier recordings may not be relevant further down the supply chain.

They can further be classified along different dimensions. Certain properties such as species and weight can be controlled at any given time through spot checks, whilst others can only be recorded at a specified moment, e.g. catch area and gear type used. At the same time, certain properties are subject to change throughout a product's lifetime, e.g. weight and product condition, whilst others are more constant, in the sense that they remain the same through a product's lifetime, e.g. catch area and method. This varies based on the product property in question as well as the demands from the different authorities.

Similarly to the observations about information collection, analysis of the registrations themselves reveals a high level of complexity. Some of the most important considerations are:

- The registrations submitted earlier in the supply chain are more specific to the product and more detailed than registrations submitted at later stages. This is due to the different responsibilities of the authorities, and the fact that not all systems are set up with the fishing industry in mind. While the Directorate of Fisheries is solely concerned with the seafood industry, the Norwegian Tax Administration and Norwegian Customs deal with a much larger range of issues.
- Some registrations are based on recordings when the event commences, while others are based on previous recordings. This means that information required at various points in the chain does not necessarily have to be recorded again. Information can therefore be based on only one single recording at an early stage. Thus, information required at later stages in the supply chain might refer to the early stages of harvesting and production, e.g. “catch location” in the export declaration.
- There is a certain degree of overlap of submitted registrations to different authorities.
- There is a lack of standardization of registrations across the different authorities and datasets, regarding both reporting routines and the unit of measurement.
- The registrations have a varying level of granularity.

In short, the preliminary study reveals a high level of complexity that must be considered when mapping comparable public registrations. There are two apparent information gaps in the supply chain. The first is related to the production process, and the second to domestic sales and consumption data, as indicated in the previous chapter. With the exception of general traceability requirements, there are no mandatory registrations filling these information gaps. Regulations on traceability follow the principle of "one-up-one-down", i.e. an operator is only required to know whom they received a product from, and to whom they sent it. They are not required to trace a product further back, nor track it further along the chain.

3.2 Case study on cod processing in Norway

To obtain information on the various records and possible discrepancies, we have collected information about recording routines in a Norwegian processing company. The company is a major producer of cod with the majority of its products destined for export. It is also fully integrated within the different stages from harvesting to sale, with everything being sold through its own sales and marketing company. The company owns several manufacturing plants, but this study has only focused on one. As the whitefish industry is highly heterogeneous with industry actors characterized by varying products, size, ownership, location, and access to raw material, the results cannot be generalized to other companies. However, the company produces a wide range of products, and therefore serves as a good example of how the different record-keeping requirements can be implemented in the different productions and which sources of errors might occur.

Two separate semi-structured interviews were conducted with one representative from the production plant and two representatives from the sales and marketing office. The interviews centred on general aspects regarding traceability, product registrations and reporting routines, the accuracy of the different registrations, and possible sources of discrepancies. For the latter part of the interview, emphasis was on the accuracy of recordings specifying product weight and species, and possible sources of error that might influence them.

3.2.1 Traceability and reporting routines

In regard to the routines for handling registrations and reporting, the interview reveals that the production plant mainly deals with the Directorate of Fisheries, Statistics Norway and the Food Safety Authority. Registrations that are of relevance to the Norwegian Tax Administration and Norwegian Customs are usually handled by the sales office, together with recordings on the transportation of goods. The sales and marketing office does not register any new information on a given product. Rather, they rely on existing information already recorded at the production stage. For this reason, any discrepancy that has occurred during the production phase is unlikely to be detected by the sales and marketing office at the point of export. The registration requirements vary slightly at the export stage, as different markets have different requirements in regard to the forms and documentation required.

During the interview, it was clarified that their ability to track, and interest in tracing, a product was limited to their part of the supply chain, with seemingly little interest in tracking a product after it left their hands. Increasingly, reporting is performed using electronic reporting systems, but the information must usually be manually gathered from the different sources such as accounting, waste separation, etc. The company has routines and the reporting responsibility is divided between different players.

The company experiences a certain degree of overlap as it often needs to write double reports to satisfy different reporting requirements even if the content is the same. This can relate to different authorities at the same stage in the supply chain and at different stages. Currently, they do not have a system that enables the takeover declaration to follow the product. One batch can be sold to many customers over a long period, and the same takeover declaration applies for all these transactions. Thus, everything must be recorded again at this stage.

Current regulations on record-keeping requirements and traceability provide few, if any, clear guidelines on systems and procedures for recording information, meaning that the systems in place will vary from operator to operator. The company has a system for tagging the fish, especially clipfish, that according to the company ensures "*100% traceability*". However, tagging is not done on a regular basis, as it is their perception that there is no demand from the market. One challenge regarding tracing the product to its original vessel is that there could be 50-60 smaller vessels per day landing from 60 to 300 tonnes of fish in total, and the catches could consist of up to ten different species. Packing the products and connecting the package ID to the correct vessel before the vessel leaves the dock is therefore very difficult.

3.2.2 Discrepancies in public records

The second part of the interview focusses on product-specific registrations, with emphasis on recordings of weight and species. The interview was based on the four categories of product-related registrations: geographic origin, time/date, product handler, and product properties.

With regards to possible sources of discrepancies in the production process, the interview reveals them to be highly product-dependent. Generally, the more processing a product undergoes, the greater the risk of a discrepancy. For whole fish, the risk of errors occurring regarding geographic origin, time and date as well as product handler is regarded as relatively low due to the products undergoing minimal processing and having a short storage time. For conventional products however, such as saltfish and

clipfish, which have production and storage times of 1-2 and 6-8 months, respectively, the risk of errors occurring is much higher. The long storage period and different product classifications mean that parts of batches can be sold over a long period, making it difficult to keep track of the different products.

Weight is recorded several times throughout the supply chain and is a central registration. In the landing phase, the risk of discrepancies occurring is regarded as low. As per international agreements on fisheries quota management, the weight is recorded in round weight, even if the fish is landed in a different condition. In this event, a national conversion factor is used to estimate the round weight. For the company in this case study, the conversion factor is not a problem as it buys everything in gutted weight. The gutted weight is automatically converted into round weight when reporting to the authorities. Therefore, the conversion factor is not an issue for the company. However, the respondent says that this could be a problem when buying the fish round. This is because the national conversion factor is often wrong, especially in the seasons when the cod graze on herring. The companies do not want to pay for the stomach contents; this is the reason why some advocate the use of a dynamic conversion factor (a conversion factor based on the actual biology of the fish at a given time).

In the production of round fish, the discrepancy is low, as the weight does not change considerably. The production of saltfish and clipfish, however, is more complex as there are more production stages, e.g. maturation, which influences the weight of the product. Since the weight is subject to change, it is difficult to accurately calculate the inventoried fish. The size of a possible discrepancy depends on the specific fish, catch method and seasonal variations. The company has experienced that the discrepancy can be quite significant.

During transport, the only recording of weight is in the internal journal, which is done manually. For fresh, whole fish, they have packing lists and full control. Weight is recorded on both boxes and pallets and is regarded as accurate. The discrepancy is higher for saltfish and clipfish.

In the export phase, weight is recorded in the TVINN data to Norwegian Customs and in this stage is the responsibility of the sales company. They own the product from the time it leaves the producer until payment from the customer is received. However, the sales company is not in contact with the product itself and relays information from the producer. As they do not control the goods, any discrepancies will not be discovered before the fish reach the customer.

As for registrations pertaining to species, the respondent reports that discrepancy in the species records is moderate. Discrepancies in the landing phase are related to manual reporting and errors that could occur in a stressful situation. The more complex the production, the more discrepancies there will be. The risk is further increased by the numerous graduations in the production of saltfish and clipfish.

3.2.3 Material flow analysis and sources of errors

As the material flow analysis in Chapter 2 shows, there is a gap between the input and output of fish in Norway. The company was asked to comment on this gap and give examples of sources of discrepancies. The general perception is that a certain gap is expected. According to the respondent, "*if the accounting adds up, you can be sure there is fraud involved*", i.e. it is impossible to compare figures and expect them to match. This difficulty is related both to biological factors as well as those related to the production process. Some of these factors are applicable to all species, while others

depend on both the degree of processing and the type of product. Biological factors that are of importance are mainly related to yield and fat content, qualities that are to a large degree determined by seasonal differences and catch area.

The possible sources of discrepancies are summarized below. The list is mainly relevant for the cod that is salted and dried, as the discrepancy for the whole fish is regarded as very low through production. The sales company did not have any knowledge on the discrepancy in the production phase, and this was not relevant in its part of the supply chain. For these respondents, a gap between the landing and export figures did not seem natural. How much of the discrepancy can be explained by each of these factors has not been estimated; a discrepancy can be caused by one factor or a combination of factors.

- Adjustment of machinery
- Lack of weighing in and out of splitting
- Maturation
- Season and quality
- Warehousing

As mentioned, the material flow analysis is based on the recorded assumed usage. As per the landing regulations, producers must state the "assumed usage" of a batch when it is landed, e.g. the percentage that will be filleted, salted, etc. In the material flow analysis, this record was used to split the different productions. As this is only assumed use, some discrepancy is to be expected. The case company states that they usually know the usage of the fish when writing the landing note, and they estimate the reliability in their production to be around 95-98%. The discrepancy is related to fresh fish that cannot be used for this purpose due to factors such as poor quality, a fall in demand or other unpredicted events. In these cases, the fish is usually salted. Comparing records between different authorities, such as the Food Safety Authority and The Directorate of Fisheries, also appears to be difficult, according to the interviewee, due to their differing focus and control and monitoring routines.

The respondent was also asked whether there is a connection between the volume records and the financial statements, and whether a discrepancy in the volume in and out can be reflected in the annual accounts. Although they continually analyse profitability and use these analyses as a tool for directing production and produce monthly internal reports, the annual accounts are not deemed suitable for controlling or discovering fraud in real time. The volume of fish involved is so large, and there is so much money circulating, that waiting for the accountant is a "*dangerous game*". At best, this is a way to obtain more knowledge on why things went wrong.

4 Discussion

In the following chapter, we discuss the findings from the mixed-method approach. First, we discuss the implications of the findings both at a general level relating to the study of food supply chains, and for the Norwegian fishing industry specifically. Lastly, we discuss the strengths and weaknesses of the mixed-method approach.

4.1 Identified sources of discrepancies

By using this mixed method approach, we are able to identify three main sources of discrepancies that can disturb the resource account: errors in the source data, errors in the material flow analysis, and fraud. Each of these sources of errors occurs for a variety of reasons. Furthermore, the responsibility can be attributed to different actors: the operator responsible for the act that leads to the discrepancy, the authority in charge of controlling the system, or limitations and human errors in the analytical method. Table 4.1 shows the identified main sources of discrepancies, the various reasons why they occur and the associated responsibility.

Table 4.1 Sources of discrepancies and associated responsibility

Source of discrepancy	Reasons	Responsible
1) Errors in source data	Errors in electronic systems	Operator and/or authority
	Human errors	Operator and/or authority
	Methodology errors	Authority
	Hidden flows	Actor and/or authority
	Information gaps	Authority
	Lack of control	Authority
2) Errors in MFA	Methodology errors	Study
	Human errors	Study
	Time lag/storage	Method limitation
	Conversion factors	Method limitation/authority
	Alternative data sources	Statistics supplier/authority
3) Fraud	Increased profit	Operator
	Survival	Operator

4.1.1 Errors in source data

Errors in source data can occur when submitting, collecting, analysing and publishing information. These errors can be systematic or occur only occasionally. As listed in the table, there are several reasons for these errors to occur. There is always a risk of errors in the electronic systems, such as incorrect settings, data transfer, etc. Electronic systems can include everything from electronic weights to computer systems in public databases. Human errors, in all parts of the supply chain, will also affect the data and will always be difficult to estimate correctly. Of course, there are ways to minimize human errors such as more use of electronic systems or an increase in control points. By crosschecking information, human errors will decrease, but is dependent on the resources available. Not only errors in the electronic systems but also human errors will depend on actions and systems made or introduced by the actors themselves and the authorities.

Methodology errors, hidden flows and information gaps are other possible reasons for incorrect source data. By methodology errors, we mean systematic errors that might arise when transforming or compiling data in different systems. Often the data used in aggregated analysis are data already processed by the owners of the data source. Hidden flows are product flows that are not recorded at any point in the chain. Often, these are associated with fraud. However, hidden flows can also be legal product flows that for various reasons are not recorded in any system. An example is the Norwegian tourist fishery. There are some estimates on the size of this fishery, but there are no mandatory requirements for catch recordings. This means that the catches that exceed the estimates are not included in the source data, but act as a hidden flow. As the tourist fishery has grown, the authorities have directed attention to this flow, and are now implementing mandatory registrations also for this part of the industry (The Norwegian Directorate of Fisheries, 2017).

In this study, we have identified two important information gaps. The first one is a lack of accurate registration of the actual usage of the fish. This meant that we had to use the registration for *assumed* usage instead. Registration of *actual* usage when production started would be very useful when breaking down the MFA on a product level. Performing MFA at product level based on *"assumed usage*" reveals that fresh products are overestimated and frozen/traditional products are underestimated. The second gap is a lack of consumption figures. As exact numbers for consumption are lacking, these have to be estimated thus constituting a major source of error.

However, implementing new registration requirements to fill these gaps is not a straightforward exercise, as shown by an evaluation of the implementation of the new landing regulations (Svorken *et al.,* 2016). The proposed regulation would require, among other things, that the processing plants increase monitoring throughout the production process; it would result in increased demands for record keeping, and necessitate more automated production systems. The proposed regulation was heavily criticized by the industry due to the potential costs associated with complying, unclear guidelines regarding approved equipment and routines, a perceived lack of need for more monitoring and control, and because it did not take into account the heterogeneity of the industry actors. In order to ensure compliance with newly introduced legislation, it is necessary that the actors who are affected perceive the regulations as responding to a need, and that they are fit for purpose. However, the factors mentioned above complicate the process of introducing a common regulatory framework which is intended to fit all those involved without compromising daily operations too extensively. It is difficult, but necessary, to design a regulatory feature that ensures legitimacy and compliance, while allowing for flexibility within set boundaries.

In general, more control functions will ensure data reliability; however, there is also the question of resources and efficiency. An example is control of the landings of fish; the Norwegian Directorate of Fisheries is only able to control a very limited part of the yearly landings, around 2% (Office of the Auditor General of Norway, 2017). The responsibility for ensuring that there are no important information gaps and that the control functions are adequate to ensure the veracity of the data, essentially lies with the authorities in charge. But the actors themselves are also responsible for having control routines. The case study reveals that it is not usual for the export company to control the weight of goods, meaning that they rely totally on the data from production. When available data are used as secondary data for statistical purposes, there is an expectation that these data are reliable.

4.1.2 Errors in the MFA

When compiling data, the results will depend on the method used. In regard to the source data, there is always a risk of human error such as miscalculation, disregarding data and so on, as well as methodology errors, depending on the method chosen, which could be data extraction, data grouping or data aggregation.

The errors in the MFA will also depend on the context. Time lag, conversion factors and use of alternative data sources are examples from the case in this study. If the chosen period is incorrect, or if warehousing from one period to another is very large, this will be visible in the results. However, when analysing time series, warehousing should be equalised between the different periods. The equation in the analysis assumes that all cod that is imported and landed in Norwegian ports in 2010 to 2017 is either consumed or exported in the same period. In practice, this is not necessarily the case.

In the case study, storage time is mentioned as a source of error, and the time lag will differ depending on product categories. Whereas fresh cod is delivered to the end customer within a few days, frozen cod and highly processed products (i.e. stockfish, dried and salted cod, clipfish) can be stored for several months. For the company in this case study, the storage time for their production is short. For them it is important to reduce the risk by following a just-in-time principle, meaning that they produce on demand from the customers and that most of the fish is purchased and sold within the same year. However, it is also important to consider that the industry is characterized by a wide variety of companies, and the market situation may differ from year to year. Abrupt increases in the quotas or other events that could influence the market can all cause an increase in warehouse stocks.

Use of conversion factors to establish a common unit of measurement can also influence the results. This could be conversion factors used in the specific study where the analysts themselves must convert the numbers to make them comparable, or conversion factors used in the source data. In our MFA, conversion factors are used both in the source data and in the analyses. Incorrect landing volumes caused by conversion factors are mentioned as a source of error both by authorities and the industry. International standards require official landing statistics to be stated in live weight, causing pre-processed products to be converted back using set conversion factors. The actual volumes might therefore be higher or lower depending on the accuracy of the factor. The conversion factor for whole cod, gutted without head is 1.5, but the actual factor can often be significantly higher, especially in the winter when around 80 percent of coastal fishing occurs. Around 67% of this fish is converted using the official factor (Kristoffersen et al, 2017). In 2016, a proposal was submitted to change the conversion factor to 1.68 for the period January to April (The Directorate of Fisheries, 2016); however, the proposal was rejected. The introduction of a dynamic factor based on the actual conversion factor at any given time has been discussed (Kristoffersen et. al., 2017) but, at the moment, use of a dynamic conversion factor is considered to be illegal by the authorities. This use of a dynamic conversion factor has also been mentioned as one of the most common methods used to cheat regulations (Svorken and Hermansen, 2014).

For the purpose of the results of the MFA, it is important that the conversion factor for the landing numbers reflects the conversion factors used when converting product weight in the output numbers into live weight. Changing the conversion factor in the analysis from 1.5 to 1.68 causes a positive discrepancy, i.e. input is higher than output, for all years, except 2010 and 2014 (Table 4.2).

Table 4.2 Input and output of cod during different scenarios

	Normal discrepancy	+6% increase in landings	Increased conversion factor (1.5 -> 1.68)
2010	-23%	-17%	-13%
2011	-4%	2%	5%
2012	0%	5%	8%
2013	-3%	3%	6%
2014	-9%	-3%	0%
2015	-3%	2%	4%
2016	-3%	2%	5%
2017	-2%	3%	5%
Mean	-5%	0 %	3 %

If use of a dynamic factor or changing the current one reflects the landing numbers more correctly, it would also reduce the margin of error in the analysis. Another way of reducing the margin of errors in the landing numbers is by avoiding the conversion factor altogether. Then it would be possible to compare landing numbers with export numbers without converting them into live weight. However, this would require accurate knowledge on the yield as well as wastage through the production phase for each product. Live weight is probably the best common denominator if it is correctly reflected by the conversion factors.

As trade and consumption data must be converted into live weight, the analysis is dependent on the volume and conversion factors. The actual factor for each fish may vary greatly; as the volumes of traditional products accounts for 35% of the total export, conversion factors that fail to reflect the actual volume in live weight will affect the analysis. If the conversion factor is too high, it will lead to an even greater negative discrepancy when the volume increases. As the yield may vary between different periods, it is difficult to determine whether the conversion factor is too high or too low during the whole period. These results substantiate the need for filling the information gap in the production phase, as the influence on the conversion factors will differ between the different products.

Table 4.3 Discrepancy when reducing and increasing trade conversion factors on traditional products by 10%

	Normal	Δ Export conversion factors	
	Discrepancy	10% -	10% +
2010	-23%	-17%	-29%
2011	-4%	2%	-9%
2012	0%	5%	-5%
2013	-3%	1%	-7%
2014	-9%	-5%	-14%
2015	-3%	1%	-8%
2016	-3%	1%	-7%
2017	-2%	2%	-6%
Mean	-5%	-1%	-10%

The transit recordings also stand out as a factor that probably should be investigated further. In this project, it has been difficult to perform a quality check on these numbers. More knowledge on how transit is recorded in the trade statistics would therefore be useful.

Use of alternative sources, or estimated numbers, when collecting data could also cause errors in the analysis. In this study, there were no public data on domestic consumption. These data were therefore collected from alternative sources that estimate domestic consumption. Even if the estimate appears reasonable, it will not be as accurate as the numbers that are required for the public records. Another challenge is that when there is no public or obvious data source available, the analyst's choice of data source and estimates can impact on the results.

4.1.3 Fraud

The last source of discrepancy is fraud. Fraud is commonly understood as "a way of making money illegally via deception" (Levi 2012:7). The goal is either to make profit or to use it as a way of surviving in a crowded market (Albanese, 2012). In other words, a distinction can be made between "greed or need" as a motivating factor (van Ruth, Huisman & Luning 2017:72). Fraud can occur in all stages of the supply chain and impact on the records. Fraudulent products can either be laundered through the supply chain or appear in a hidden flow outside the system. In the first instance, this will become visible when comparing data, as in a Material Flow Analysis. The latter, however, will not be visible in any records, and cannot be discovered this way. Notwithstanding, if the crime relates to extracting a scarce resource, this will eventually become visible in biological calculations.

The party responsible for committing fraud are the actors themselves when they choose to act outside the law. However, there will usually be certain drivers for fraudulent actions associated with the supply chain, regulation issues, competition issues or demand, etc. (Albanese, 2012). Examples of drivers can include gaps in control functions facilitating fraud, or industry and market conditions that can make the act of fraud appear a rational choice, e.g. an uneven power balance between actors, volatile pricing mechanisms, etc.

In a survey on illegal fishery in the Norwegian cod fishery, Svorken and Hermansen (2014) describe some of the most common ways to commit fraud. The most used methods include reporting lower volumes of fish than that actually landed, and the use of conversion factors other than the official factors. The reporting of lower volumes is often due to poor quality of the fish. When the fish is of poor quality, the price of the fish can be reduced. However, instead of reducing the price, the fishers deliver more fish than that written in the landing note. The price in the landing note therefore appears normal compared with the market price but, in reality, the price per kilo is reduced. Other ways of committing fraud, though not as common as those previously mentioned, include reporting a fish as a different species, dumping of fish either at sea or at the docks, and registering the batch as having been fished by a different vessel.

4.2 Why does the discrepancy peak in some years?

As the MFA shows, 2010 and 2014 display significant anomalies in regard to the time series, when the gap between input and output peaks at 23% and 9% respectively. Figure 4.2 shows a more detailed description of the figures for 2014.

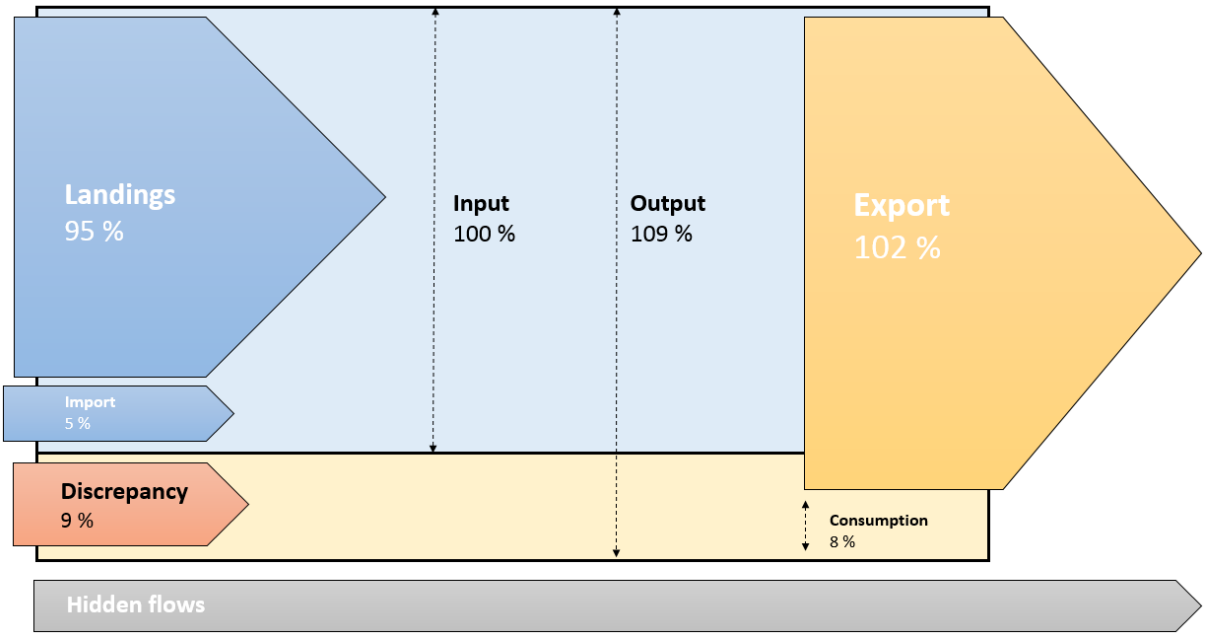

Figure 4.1 Input and output of cod in 2014 showing a discrepancy of -9%

Possible underlying causes contributing to the sources of errors identified, can be found in the annual summaries of the fisheries regulations from the Directorate of Fisheries (The Directorate of Fisheries, 2010-2017), the landing statistics and the export statistics.

Both in 2009 and 2013 the market for cod was challenging. In 2009, this was partly due to a combination of the financial crisis that occurred in 2008 (Dreyer & Bendiksen, 2010) and a 21% increase in the quota. In 2013, there was another increase in the quota by 32% from the previous year. This abrupt quota increase further exacerbated the difficult market situation and led to capacity problems in the processing plants. The cod quota was not fully fished, and there was a build-up of stocks (The Directorate of Fisheries, 2014). The landing numbers show that a larger share of the total catch was landed at the end of the year in both 2009 and 2013 compared to other years. While the average share of the catch landed in November and December is around 6% in other years, in 2009 and 2013 this share is 10%. As a time lag of a few days or a few weeks is to be expected, it can be assumed that much of this fish was registered as export the following year. The export numbers for 2014 support this assumption, showing that export was higher at the beginning of the year compared to other years. The figures also show that in 2010 and 2014 the exported volume of traditional products, i.e. products with a longer production and storage time, was higher than normal.

However, it is worth noting that the warehouse build up in 2013 is not apparent because the discrepancy in 2013 does not equalize the discrepancy in 2014. If parts of the landings at the end of 2013 are transferred to the input in 2014, the negative discrepancy will peak in 2013 rather than 2014. In regard to 2009, because the starting year for the MFA is 2010, we are not able to tell if a potential warehouse build up in 2009 is visible in the discrepancy the following year.

The market situation also led to a free fishery for the coastal fleet from the start of the year until early April. A free fishery can result in a strong focus on quantity, something that could lead to poorer quality of the fish and, thus, reduced yield. According to the Norwegian Fishermen's Sales Organization (2018), 2014 had a larger share of low-graded fish in the period when there was a free fishery than in the other

years, indicating that the quality was poorer than normal. Thus, based on the lower yield in 2014, coupled with the larger export of highly processed products, it is possible that the conversion factors in consumption and trade constitute a major source of error for 2014.

As well as being the principal source for the factors mentioned above, the challenging market situation could also act as a catalyst for fraudulent actions, leading to an increased discrepancy caused by fraud. As mentioned previously, poor quality is a known issue when pricing the fish, where instead of decreasing the price due to poor quality, the fishers deliver more fish than that written in the landing note (Svorken and Hermansen 2014). This, along with other issues such as lower prices per kilo due to a downturn in the market, may cause the industry actors to be more inclined to commit fraud.

However, the converse might also be true. There appears to be an increase in rumours surrounding fraud when there is a big shift in the quotas (Dreyer, 2015), as in 2013. Due to the rumours regarding misreporting in 2013, the focus on control was stronger in 2014, with a resultant increase in the risk of being caught compared to the previous year, a factor that might also act as a deterrent. From this perspective, a discrepancy caused by fraud could have actually been lower in 2014 than in the other years. Combined with the fact that we are not able to see the warehouse build up in 2013, it is likely that any discrepancy caused by fraud stems from misreporting that occurred in 2013, and not in 2014.

We are not able to delineate the degree to which these factors can explain an increased discrepancy in some periods as that requires more in-depth studies. However, the quota and the market situation appear to play an important role. Other drivers such as conversion factors in the landing phase, vessel capacity, and availability of cod should also be investigated. However, to our knowledge these drivers do not differ in 2014 from the other years included in this study.

4.3 Evaluation of the mixed-method approach

The model presented here proves useful as a tool for mapping the flow of goods in the Norwegian cod fishery; nonetheless, certain issues must be taken into account when utilizing this type of methodology approach.

The supplementary regulatory framework analysis and case study both provide good insight into specific sources of errors that could influence the veracity of the model. However, while the regulatory framework analysis provides an overview of product registration requirements, it is not necessarily exhaustive. Although the list of registrations is based on a review of the regulatory framework, and has been validated by the applicable authority, gaps could exist. This could be the case in particular when specific conditions apply to certain products, either through specific regulations or due to exceptions from the regulatory framework. Furthermore, in the present case, the overview does not specify details such as the units used in the particular registrations, e.g. whether weight is required to be recorded in kilos, rounded off to the nearest ton, etc., nor does it specify technical details regarding electronic transfer of data such as formats, use of UIDs, etc.

While these shortcomings can be overcome through additional interviews with authorities as well as a more extensive mapping of the registration requirements and available systems, this would potentially be highly costly and time consuming. In addition, while this would provide a much more detailed picture, it does not necessarily provide information on how things are handled in practice. In many instances, the regulatory framework provides only overall guidelines for the actors to follow,

and at times allows considerable room for individual adaptation. This means that it does not reflect how food business operators handle traceability systems and product registrations in practice. A study intended to investigate and shed light on the full complexity of product registrations would have to be coupled with an equally complex study of food business operators' practices. A traditional semi-structured interview such as the one used here is not suited for that purpose since it involves information that is difficult to convey in such a setting. While techniques such as workshops can be used with good effect and could potentially prove viable, they are highly time consuming and demanding for both the interviewee and the person conducting the study. This consequently limits the number of businesses available for study.

In other words, mapping all registration requirements along a supply chain, as well as studying how these requirements are handled in practice will not be feasible, in most cases, due to the time and costs associated with such detailed mapping. The benefit can also be questioned: it would introduce a level of complexity that does not necessarily correspond to the added value it brings to a study with an endpoint similar to the one presented here.

Since the study involves only one case study, the results cannot necessarily be generalized to other food industries, nor other industry actors within the fisheries sector. However, as this was a feasibility study, generalizability was not the aim. Future studies based on this approach should include a wider variety of industry actors, representing either a single or multiple production. As one of the conclusions in the case from the Norwegian fishing industry is that the discrepancy when balancing input and output is strongly dependent on *product*, it would be useful to have enough interviews to cover all the main productions (fresh/frozen round fish, fresh/frozen fillet, and traditional products like stockfish, saltfish and clipfish). It should be noted that any approach that includes case studies will have a limited potential with regards to generalizability regardless of the number of case studies included. The degree to which this represents an issue will depend on the makeup of the industry in question; actors in one industry can be highly homogenous, while in other industries they can be highly heterogeneous. The number of interviews would have to balance the available time and costs.

5 Concluding remarks

In this report, we have used a mixed-method approach, comprised of mass balancing combined with mapping of the regulatory framework and an in-depth case study, to highlight sources of discrepancies throughout the supply chain.

The mass balancing approach is useful for identifying discrepancies and anomalies, but it does not detect fraud, as such. It should be used as a supplement to other methods, rather than as a stand-alone tool. A broad approach can increase detection and can generate more evidence for the authorities when unregistered commodities are laundered through production. In Norway, the analysis supports the knowledge and rumours around misreporting of cod in 2013. Moreover, a more detailed level would be preferred to aggregate level. However, this is dependent on data availability. In industries where there is a lack of recordkeeping, the analysis should be supplemented with non-mandatory records, e.g. consumption estimates as used here, or internal company data, if available.

Mapping the regulatory requirements governing product registrations reveals the complexity of the governing framework. While many registration requirements exist along the supply chain, and a certain degree of overlap can be found, some information gaps are identified; most notably the lack of registrations recording the actual usage and domestic consumption. Furthermore, there is no overarching system for gathering and sharing data with the aim of preventing fraud specifically, as noted by Ekerhovd et.al. (2015). Notwithstanding, the analysis shows that it is possible to compare data from the Directorate of Fisheries and Norwegian Customs. Other data are available but are not standardized, and therefore are difficult to use in an analysis such as the one presented here. A common platform is necessary for gathering, storing, and exchanging data between authorities. This would reduce the burden on the industry actors in regard to reporting, as well as improving the potential for control and monitoring. Improved systems for monitoring the product flow could also shed light on the hidden flow, i.e. products which are not recorded at any point in the supply chain.

This lack of control and unreliable data in some areas, coupled with the uncertainty surrounding the conversion factors used in the landings, export and consumption figures, mean it is difficult to estimate exactly how much of the discrepancy can be attributed to intentional acts of fraud, and what is attributable to unintentional errors and other non-fraud related factors. These weaknesses only contribute to the recurring rumours surrounding illegality in Norwegian fisheries and, if not remedied, will substantiate them further, leading to increased speculation and few answers.

Regardless, the recurring rumours surrounding fraud in the Norwegian fishing industry is an indication that the problem exists, even if the scope is unknown. The drivers behind committing fraud may differ. For some it might be enough that the opportunity is there, while others might see fraud as a "last resort" to survive in an industry where profit margins are slim, the power balance between actors at times uneven, and where fluctuations in quotas and prices might put them at risk. Differentiating between increased profit and survival as motivating factors is not a trivial distinction; in order to be able to take effective action against this problem, the true cause of and motivation for fraudulent behaviour must be investigated further.

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Appendix

Appendix 1 – Main authorities involved in controlling the cod supply chain

Authority	Objective	Legislation specifying registration requirements
Directorate of Fisheries	Advisory and executive body of the authorities in fishery and aquaculture management in Norway. The Directorate enforces the fisheries regulations at sea, landings and export. The resource control consists of both physical control and inspections during the operations and analytical control of registrations and statistics. The control is based on a national risk assessment compiled in collaboration with the Coast Guard and the Fishermen's sales organizations.	*Reg. on position reporting and electronic reporting for Norwegian fishing vessels (FOR-2009-12-21-1743)* *Reg. on electronic reporting for Norwegian fishing vessels under 15 metres (FOR-2014-12-19-1822)* *Reg. on storing electronic catch and position data from fishing vessels (FOR-2010-05-11-681)* *Reg. on landing note (FOR-2014-05-06-607)* *Reg. on catch certificate (FOR-2009-12-18-1693)*
Norwegian Food Safety Authority	The main objective of the Norwegian Food Safety Authority (NFSA) is to ensure that foodstuffs and food products including drinks are safe for consumption, and to promote animal health and welfare. The NFSA carries out supervision and control along the whole of the supply chain, i.e. harvesting, production, transport, import/export, and sale to consumers within Norway. The NFSA control routines consist of inspections of facilities, audits/document control and sampling.	*Reg. on food hygiene (FOR-2008-12-22-1623)* *Reg. on animal by-products not intended for consumption (FOR-2016-09-14-1064)*
Norwegian Customs	The Norwegian Customs' main objectives is to protect against prohibited and restricted goods, facilitate correct and efficient import and export, and to ensure government revenue through customs duty, VAT and special taxes. Thus, keeping track of product flow in and out of the country is a necessity.	*Reg. to Act on customs duties and movement of goods (FOR-2008-12-17-1502)*
Norwegian Tax Administration	The Norwegian Tax Administration has the administrative responsibility for the National Registry and is responsible for the collection of taxes and charges to make sure that the welfare state is properly funded.	*Norwegian Accounting Act (LOV-1998-07-17-56)*

Appendix 2 – HoReCa Conversion Factors

Group		Classification	Conversion Factor
1502	Fersk torsk, Sprengt, salted, røkt	Fersk	2.150565773
1522	Fryst torsk, Sprengt, salted, røkt, marinert	Fryst	2.150565773
1508	Klippfisk, Tørrfisk fersk, Inkl. boknafisk	Tradisjonelle metoder	1.204233829
1528	Klippfisk, Tørrfisk fryst, Inkl. boknafisk	Tradisjonelle metoder	1.204101571
1509	Lutefisk, fersk	Tradisjonelle metoder	1.19
1510	Lutefisk, fryst	Tradisjonelle metoder	1.28
1314	Torsk, hel (fryst), Hel, sløyd, skiver	Fryst	2.588864736
1315	Torsk, filet (fryst), Filet	Fryst	2.83
1114	Torsk, hel (fersk), Hel, sløyd, skiver	Fersk	1.5
1115	Torsk, filet (fersk), Filet	Fersk	2.83

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