11 Actors and innovators in the circular bioeconomy

An integrated empirical approach to studying organic waste stream innovators

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11.1 Introduction

This chapter addresses the need for a reliable way to identify actors in the 'bioeconomy' and to take stock of the innovative activities they engage in, especially in terms of how these activities involve organic waste paths and the circular economy. The focus is on what the actors do, not how they are initially categorised. Economic actors engage in activities that they either directly associate with the bioeconomy or that can be associated with the bioeconomy via scientific activity. We have screened a comprehensive range of available data sources based on both more objective measures (e.g. patents or projects linked to the bioeconomy) and on more subjective links (e.g. affiliation with relevant interest organisations, or survey responses). This identification procedure yields a population of actors whose contribution to the bioeconomy can be linked to one or more measures, allowing us to say something about the population itself as well as the activities that the actors are involved in that contribute to the bioeconomy.

The chapter starts by introducing the basic challenges that emergent and/or sector-bridging industries face, before laying out an identification procedure to help stabilise that population and their activities. We then explain the approach we use to identify actors according to clear criteria based on a range of available data sources. The chapter has three empirical sections:

- i R&D baseline: The first section establishes a baseline for research in the bioeconomy, starting with the most standard measure possible, official national research and development (R&D) statistics. It builds on a customised study carried out in Norway in 2016 using 2015 data (Rørstad & Sundnes, 2017).
- ii Population of bioeconomy firms: The second section reports on the empirical strategy used to flesh out the who and what of the emerging circular bio-economy. The Norwegian Inventory of Bioeconomy Entities (Iversen, 2018), which systematically integrates R&D, patenting

and project data, is used to identify 'economic actors' involved in the circular bioeconomy, highlighting the six subsectors considered in the previous book chapters. 'Actors' are primarily private-sector entities ('firms') but may include research organisations in the governmental sector such as research institutes, universities, etc.

iii Survey of bioeconomy innovation: Finally, the chapter presents results from a novel firm-level questionnaire that focused on innovation in organic waste activities in Norway in 2017. The population-frame for this mapping exercise, which was carried out at the TIK centre (University of Oslo), came from the NIoBE dataset. The survey also provides a quantitative backdrop to the cases previously presented in this book within specific subsectors.

Together these steps provide a consistent and comprehensive view of the actors and their activities and how they contribute to the emerging circular bioeconomy in Norway.

11.2 Background[1]

The inaccuracy of industrial classifications for emerging fields and sectors: Addressing the question of who is involved in the bioeconomy acts as a stumbling block for empirical and policy-relevant research. Recognised industrial classifications, such as the NACE taxonomy (Statistical Classification of Economic Activities in the European Community), are not reliable guidelines in this context. This is because the bioeconomy is emergent and not yet fully stabilised as a recognised and distinct field; instead, it continues to take shape as existing sectors utilise both new and existing technologies, inputs and ways of (inter)working to explore emergent possibilities. A deductive approach to defining the bioeconomy based on the existing foundations of established industrial classification does not get us very far and may even lead us down the wrong road.

Industrial classifications are also unreliable here for another reason. The bioeconomy is largely a meta-sector that extends across more narrowly defined industries. In many cases, the products of activities here are not new: outputs, such as energy, may simply be substitutes for established activities that use other inputs. This raises its own set of problems in creating reliable metrics (see discussions elsewhere, e.g. OECD, 2018).

Current approaches: There are ongoing activities to capture the bioeconomy in figures. These efforts are especially current in jurisdictions where policy intervention is targeting this nascent sector or area. This includes the OECD countries in general and Europe in particular. To match the focus of European policy-makers, the EU statistical agency (Eurostat) has recently attempted to coordinate data-collection efforts across Europe. These have a focus on primary biomass production and on waste resources.

Establishing the industrial sectors related to economic activity that can be categorised under the bioeconomy is more difficult. One EU project (BIC

Consortium, 2018), for example, tries to estimate the boundary of existing sectors and presents the turnover linked to these estimates. In addition, there are a number of other national (LUKE Natural Resources Institute Finland, 2018) and sectoral efforts, such as for the cellulose industry (CEPI, 2018), and cross-sectoral efforts available as data sources for bioenergy and biofuels (EurObserv'ER, 2018).

Metrics for the bioeconomy are largely based on estimates of how biomass production (agriculture, forestry, fisheries) is processed/refined in discrete sectors (food and beverages, paper) to produce organic-based products. The first problem is that this relationship is not one-to-one. Estimates are used to allocate subpopulations of established categories (like chemicals and plastics) to the 'bioeconomy', based on various estimates.

The most formalised efforts focusing on the bioeconomy involve measures of biomass and 'organic residuals' or 'side-streams'. New rules have been introduced to more accurately account for the generation and treatment of real resources. In Europe, the more accurate measures of organic waste are in keeping with the revision of statistics in line with Eurostat WStatR. However, this data is not linked directly to the firm level (yet). In the case of Norway, the revision of sector-based estimates (before 2011) to improve data collection exposed estimation errors of up to 100%. This suggests a need for a stronger micro-level foundation for accounting in this area.

The problem extends further, notably to our ability to map not only economic activities that produce organic residuals or 'waste', but also those that process them: it is difficult to properly size up the bioeconomy. However, efforts to link economic activity to biomass, such as those undertaken by EuroObserv'ER, should be encouraged. Being unable to frame the bioeconomy reliably and accurately in metrics has important consequences. We highlight the difficulties in properly framing and focusing on the role that innovation plays in the circular 'bioeconomy'.

11.3 Empirical sections

There is a range of ways to design a procedure that can identify the target population in these circumstances. As sizing up emerging technologies, industries and sectors is not a new problem, the chapter references the sectoral systems, transition literature and other current work (e.g. Bugge, Hansen & Klitkou, 2016; Rotolo, Hicks & Martin, 2015). We also refer to ongoing work in the SusValueWaste project (see note 1) using project and CV data to explore empirical ways of getting a handle on the question of knowledge and competencies. Improving the measurement of an emerging sector or meta-sector like the bioeconomy boils down to evolving metrics along the following dimensions:

- Coverage of supply and demand side measures for resources, activities and actors;

- Compatibility across countries and across time;
- Granularity in terms of the actors involved and their activities;
- Timeliness; and
- Replicability and legitimacy.

The following section will present a first estimate of formal R&D activities, the population and the survey based on this population. Two of the lenses featured here are based on collecting data from the actors themselves: the Agrifood R&D carried out by NIFU (Rørstad & Sundnes, 2017), and the survey of Norwegian firms engaged in organic waste activities carried out by TIK in 2017 (Normann, 2018). These two collection rounds are census-based activities rather than sample surveys. Each is based on an established (notionally) complete list of entities (for the defined categories); established criteria have been applied and respondents and non-respondents have been validated. This provides a point of departure that is distinct from other efforts (such as Biosmart (2018)) and that can reveal something new about the extent and direction of R&D allocations and innovative activities respectively.

We address the following questions:

- Who are active 'bioeconomy' actors in Norway?
- What activities do the different subcategories report?
- How do these activities square with related activities within the sector?

11.3.1 Baseline: R&D activity in the circular bioeconomy

NIFU, which produces the official R&D statistics for the higher education sector (HES) and the research institute sector in Norway, conducts extended census work to look more deeply into thematic areas of specific interest such as polar research, climate change or 'agriculture and food' research. We utilise the results and the population frame from the study of 'agriculture and food' R&D to set the baseline for sizing up the circular bioeconomy in Norway. The term 'agriculture and food' corresponds to the following categories in the Web of Science database: agriculture economics and policy, agricultural engineering, agriculture, dairy and animal science, agriculture multidisciplinary, agronomy, food science and technology, forestry, and veterinary science.

Conducted in 2015/2016 (reference year 2015), this national survey mapped the allocations of Norwegian actors to R&D in the area of agricultural and food-related R&D. Agriculture and food research is admittedly not a perfect proxy for the research area we wish to capture. However, agriculture and food research does provide an instrumental foundation from which to start to size up actors and activities: it spans a number of important industries that focus on organic matter and waste streams; it involves a range of commercial activities; and these activities are relatively research intensive within our scope of interest.

The population frame of the survey includes all departments in the higher education sector (84) and the research institute sector (47) who report R&D expenditures in this area and/or publish in this area. A further 462 private sector actors were included. This population represents a full count of firms that receive research, development and innovation (RD&I) grants from the Research Council of Norway in relevant fields. Over 80% of the entities canvassed replied. Information from 230 research active entities is used in the analysis.

The basis of our analysis is thus all entities who receive public money to finance research, development and innovation activities in the area of agriculture and food. This represents a quasi-totality of research activity, and the selected lens provides a census for this important part of the bioeconomy. The university (HEI) and the research institute (RI) sectors are known to be key in this research area. R&D resource allocation, including expenditures, is reported by the institutions themselves, based on a breakdown of in-house activities. The departments in the higher education sector (HES) and research institutes reported a percentage of their R&D activity which was defined as agricultural and food-related R&D. Firms in the industrial sector reported on actual amount spent on R&D in that particular research field. The questionnaire then asked all respondents to break down the agricultural R&D into thematic sub-fields which included circular bioeconomy. The numbers on R&D in circular bioeconomy are therefore estimates made by the R&D performers themselves.

Agriculture and food R&D totalled NOK 2.4 billion and has grown at an annual rate of about 2.4% in real terms between 2007 and 2015. A total of 2,900 researchers were reported to be involved in R&D activity in this area in 2015 (Rørstad & Sundnes, 2017). It should be noted that this approach does not include the important activities of ocean fisheries and aquaculture.

Table 11.1 provides a breakdown of R&D expenditures that were allocated to the area of 'circular bioeconomy' in 2015. The study defines

Table 11.1 R&D expenditures on circular bioeconomy (million NOK) per sector of performance and number of institutions/firms in 2015

Sector of performance	*Circular bioeconomy (million NOK)*	*Circular bioeconomy, share of total R&D (%)*	*Circular bioeconomy, share of agricultural R&D[1] (%)*	*Number of institutions/firms with circular bioeconomy R&D*
Higher education sector	29	0.2	9	16[2]
Research institutes	164	1.2	16	17
Industry	291	1.0	27	84
Total	485	0.8	20	117

Source: NIFU Report, 2017, p. 2.

Notes
1 Total agricultural R&D expenditures in 2015 were 2.4 billion NOK.
2 The 16 HEI departments were located at seven higher education institutions.

knowledge about the 'circular bioeconomy' (Rørstad & Sundnes, 2017, p. 12) as 'knowledge that contributes to the efficient utilisation of bio-based resources, products and residual-inputs so that they remain in the economy through multiple stages (of production and utilisation)' (translation by the authors).

The R&D study illustrates that roughly 120 actors carried out R&D for the circular bioeconomy for 485 million NOK in 2015. The private sector accounted for 60% of this activity, the research institute sector for 1/3 and the rest was carried out by the higher education sector. Activity is not evenly distributed through the RD&I system. Instead, there are a handful of dominant actors that account for the lion's share in each sector. Although seven institutions in the higher educational sector and 17 research institutes performed R&D in this field, the clear majority was carried out by organisations located at or close to the Norwegian University of Life Sciences.

Compared to the total R&D volume in Norway, the circular bioeconomy is a minor field and accounts for less than 1% on average and varies from 0.2% in the HES to around 1% for both the institute sector and industrial sector. However, the bioeconomy R&D volume is not negligible compared to the agricultural R&D. In total, bioeconomy accounts for 20% of total agricultural R&D, but the shares vary across the sectors. The highest share of bioeconomy is in the industrial sector, with 27%, followed by the research institutes with a share of 16%, while only 9% of HES agricultural R&D occurs within the bioeconomy. These findings imply that R&D within bioeconomy is a type of applied research that is likely to be conducted at firms and research institutes rather than at universities. Moreover, the research performers in each sector are not evenly distributed. Around 80 firms conducted R&D in this field, while the numbers of research performers in the other sectors were 17 research institutes and 16 university departments.

11.3.2 Population frame: establishing the NIoBE inventory of active bioeconomy actors

This R&D expenditure data provides a valuable starting point from which to take stock of the actors that are active in the circular bioeconomy in Norway. The effort to create a stable and robust population that can be used in different empirical exercises is dubbed the Norwegian Inventory of Bioeconomy Entities (NIoBE). It was initiated at NIFU in 2015 (Iversen, 2018). An earlier iteration of NIoBE is presented in Iversen and Rørstad (2017). A current version is now being finalised as a reference tool. NIoBE is designed to address the overriding question, 'Who is involved in bioeconomy innovation in Norway?', from which it can focus on more specific areas of the circular economy.

We go on to outline the identification procedure behind NIoBE before presenting some key dimensions of the resulting population. This stage is then used as a population frame for the questionnaire-based exercise carried out by the University of Oslo in 2017 that focused on mapping organic waste-related activities in the following subsectors: forestry, aquaculture and seafood processing, beer brewing, meat processing, dairy, and organic waste processing. This study will be presented in section 11.3.3.

11.3.2.1 Identification strategy of the Norwegian Inventory of Bioeconomy Entities (NIoBE)

The approach used in this research to identify a target population of active organisations in Norway included two main stages. The *first stage* involved collecting and collating a first estimation of the population. We used three types of data to open the population. The inclusion rules moved from the more stringent (the entity is involved in RD&I activities in the area, as in the example above), to an intermediate level of accuracy (the entity has been identified by another systematic project), to a more generic association (the entity is a member of a population that is nominally associated with the bioeconomy).

This first stage, which is akin to using three nets with different meshes, was designed to include as many of the true population as possible (i.e. maximise 'recall'). It is clear, however, that as we progress from the narrow to the more broad-meshed nets, we risk including considerable bycatch in the form of entities that are not a part of the true population. It proved difficult to weed out these 'false positives' from our population as the 'true' population is not known. Therefore, a *second stage* was undertaken. In this stage we set out to increase precision by using other standardised information to exclude entities that were clearly not part of the population. In particular, we used industrial classifications (NACE, which is the starting point of other studies) and other firm-level information, such as 'trade descriptions' found in financial data sources. In the following, we briefly present the three components of our approach before fleshing out the resulting population.

11.3.2.1.1 CONFIRMATION BY ACTIVITY

The first inductive stage of the approach establishes a stable foundation. It identifies Norwegian actors – universities, research institutes and firms – using data on RD&I activities that are recognised to advance the 'bioeconomy'. In this stage, recognised definitions are employed by impartial authorities in three contexts:

1 The R&D survey that demonstrates that the entity is actively involved in innovative bioeconomy activities as described above in section 11.3.1.
2 Research and innovation projects funded by the Bionær programme at the Research Council of Norway as described in Chapter 10.
3 Patenting activity in the bioeconomy area based on the Cooperative Patent Classification (CPC) (particularly the taggings under Y02W,

targeting climate change mitigation technologies related to wastewater treatment or waste management), but augmented by the work of WIPO, the OECD and other work that links patenting to the bioeconomy. The approach is elaborated on in the EU report (Frietsch, Neuhausler, Rothengatter & Jonkers, 2016) and by Kreuchauff and Korzinov (2017).

The external authorities that delimit the activities include patent examiners, funding organisations, university administrations and other researchers. They use recognised criteria to determine what constitutes the 'bioeconomy' in relation to innovative activities. Entities that conduct R&D, that engage in research and innovation activities and/or that patent novel products or processes according to clearly relevant criteria are strong candidates as innovative contributors to the Norwegian bioeconomy. The narrow definition of this first phase yields 900 firms and other actors.

11.3.2.1.2 CONFIRMATION BY EXISTING STUDIES

A second phase uses a broader identification procedure to help eliminate false negatives, and reduce the likelihood that we were excluding members of the 'true' population. In this phase, the identification strategy was loosened to include other sources where the tie to the bioeconomy had been confirmed either by other studies and/or by some form of explicit self-identification with the bioeconomy.

The sources include two earlier studies that have tried to establish populations of bioeconomy firms, one primarily focusing on the primary industries and the other primarily focusing on waste and recycling. The first study we used to firm up the bioeconomy population was the Biosmart survey (Biosmart, 2018). Given the lack of a pre-established population of bioeconomy firms, this survey was sent out by another Bionær project to many actors in the primary industries (Bjørkhaug, Hansen & Zahl-Thanem, 2018). BioSmart's wide net approach yielded a small set of respondents (650 firms) who confirmed involvement in the bioeconomy according to the definition that was provided by the survey. This form of self-identification arguably provides a strong, although more subjective, signal.

The second study takes a complementary approach and is focused on a complementary section of the bioeconomy. The study was conducted by Menon (Espelien & Sørvig, 2014), and was sponsored by Oslo Renewable Energy and Environment Cluster (OREEC, 2018), and set out to map Renewable Energy and Environmental Technologies in Norway in 2014. This study was primarily deductive: it used industrial categories (NACE) to select entities from national register data that fell into environmental technology categories: renewable energy, environmental technologies and services, and relevant parts of the electricity distribution industry (largely related to hydroelectric power in Norway). A supervised review of these entities led to a final list based on input from the branch expertise of the OREEC team.

This population was further pared down (removing 200 entities) in order to exclude the non-organic sections of the population and to focus on the area of bioenergy and circular economy related to organic waste.

11.3.2.1.3 CONFIRMATION BY ASSOCIATION

To ensure that we had not excluded any target entities, a final analysis of the population was conducted. Here we use two registers of entities that have a strong but more nominal association with the bioeconomy. The so-called 'Biodirectory', which originated in 2016, showcased 80 entities that had been involved in research programmes into sustainable technologies including those funded under the Centres for Research-Based Innovation (SFI) and the BIOTEK2021 Programme (BIOTEK2021, 2018). Half of these entities overlap with either the project data or the patent-data already presented.

The other Biodirectory entities overlap with our final source, namely the relevant branch organisations from the Norwegian Confederation of Companies (NHO) and the Federation of Norwegian Industries (Norsk Industri, 2018). Branch organisations were included in dialogue with the organisations themselves and include those dedicated to wood processing, recycling, seafood and aquaculture, as well as the broad category of food and beverages. More than half of the members fit other identifiers in our approach. The remaining entities are less certain and can be excluded depending on what NIoBE is being used for.

11.3.2.2 The Norwegian Inventory of Bioeconomy Entities (NIoBE)

In the first stage, we once again focused on improving the 'recall' of the identification procedure by casting our nets wide enough that we did not prematurely exclude potential candidates of the 'true population'. This stage yielded a gross population of 2,792 entities, which can be considered an upper bound for the population. The overall population entities may be narrowed according to the focus of the analysis. For example, firms that are identified through more than one lens arguably yield the most robust identifier and could be the focus. In other cases, a broader population may be useful.

In the subsequent step, we collected a variety of information on this gross population. The industrial affiliations of the entities by NACE or by other markers of activities, such as the trade descriptions found in financial data in the AMADEUS dataset that Bureau van Dijk harvests from company annual reports (Nelson & Rosenberg, 1993), provide information about the activities of the firms: this is instrumental information that can be used to make informed decisions about which types of firms fall outside the boundaries of the circular economy. On this basis the firms were first graded by their apparent relevance to the circular bioeconomy (core, secondary, periphery) and then arranged according to the six categories studied in this project: breweries, aquaculture, dairy, meat processing, waste processing, as well as a seventh category, residual population consisting of other research activities.

Table 11.2 breaks down the resulting population of 2,369 firms by type of sector (based on NACE) and by the mode by which the entity was identified. We have excluded actors from our last identification phase if they feature in the NIoBE population solely due to membership in an interest organisation within the broad area of food and drinks or in generic industries that do not directly involve biomass. We found that 419 firms allocated to the bioeconomy population were based on more than one stage of the identification procedure. More than half of the entities from the R&D data overlap with other bioeconomy markers, while one third of the patenting firms also do so. This overlapping category (first column) is arguably the most robust population for framing the bioeconomy population, although it is biased towards larger firms which have a higher probability of appearing in multiple firm populations.

In general, entities in the BioSmart Survey are sole proprietor companies (i.e. very small firms) while other categories such as membership in relevant Federation of Norwegian Industries (NHO) and patenting firms tend to characterise larger firms. Table 11.3 illustrates the breakdown of the NIoBE population based on size classes in terms of the locations of the entities, which are spread throughout the country. We note a larger concentration of sole proprietorships (e.g. farms or forestry companies) in more rural areas of the country. The large population centres of Oslo and Akershus account for many of the larger firms in the population, as do the other population centres of Trondheim (Sør Trøndelag), Bergen (Hordaland) and Stavanger (Rogaland).

Some areas of Norway are more rural and rely more on primary industries; others are more urban and service-oriented; while still other localities are mostly dependent on manufacturing. These differences in the economic landscape influence the question of where circular economy activities take place. Table 11.4 classifies the location of the entities using Statistics Norway's 'classification of municipality groups' (SSB, 2018); it illustrates how the different economic activities are distributed across different parts of the country.

Primary industries – forestry, aquaculture and seafood processing, brewing, meat processing, dairy, and waste processing – are seen here to be spread throughout the country, as are the entities that produce food and beverages. The utilities classification includes recycling firms as well as bioenergy entities. These are more concentrated in population centres, as are the universities (education, etc.) and R&D service companies. Non-private services include interest-organisations and government organisations – whose involvement is qualitatively different from that of other entities in the inventory.

The Norwegian Inventory of Bioeconomy Entities (NIoBE) can thus be used to provide a systematic look at the 'circular bioeconomy' in terms of the actors who actually work with organic resources. The inventory of firms provides a great deal of information about who is involved in the circular economy in Norway. However, it does not in itself provide information

Table 11.2 Population of bioeconomy actors in Norway: by sector and identification source (n = 2,369)

Sector	*Overlap*	*R&D agricult. & food 2015*	*Patents*	*Projects*	*BioSmart survey*	*OREEC register*	*Confederation members*	*Grand total*
Primary	**37**	**8**	**12**	**64**	**483**		**29**	**633**
Farm	22	7	1	48	363			441
Fish	10	1	5	9	17		29	71
Forest	3			6	103			112
Other resources	2		6	1				9
Manufacturing	**110**	**25**	**72**	**79**	**48**	**15**	**28**	**377**
Food & drinks	70	15	4	38	20	1	22	170
Other production	40	10	62	41	28	14	6	201
Other resources			6					6
Utilities	**164**		**13**	**11**	**20**	**430**	**5**	**643**
Construction	2		7	6	1	8		24
Electricity	26		5	4	6	72		113
Recycling	136		1	1	13	350	5	506
Services	**105**	**21**	**145**	**207**	**43**	**85**	**24**	**630**
Other Activities	7		12	54	1			74
Other Services	12	5	20	29	2			68
R&D services & education	38	7	95	71	22	25	4	262
Wholesale & retail	48	9	18	53	18	60	20	226
Public & other activities	**3**		**6**	**76**	**1**			**86**
Other activities	3		4	54				61
R&D services & education			2	22	1			25
Grand total	**419**	**54**	**248**	**437**	**595**	**530**	**86**	**2,369**

Source: NIoBE, 2018.

Table 11.3 Reduced NIoBE population of bioeconomy entities by employment class and county ($n = 2{,}113$)

County	*Sole proprietorships*	*Micro-firm*	*Small firm*	*Medium-sized firm*	*Large firm*
AKERSHUS	38	68	43	26	16
AUST-AGDER	17	16	11	2	0
BUSKERUD	28	53	32	14	1
FINNMARK	6	13	13	3	3
HEDMARK	35	47	29	18	5
HORDALAND	32	50	41	23	15
MØRE OG ROMSDAL	19	55	41	14	4
NORD-TRØNDELAG	25	29	14	15	2
NORDLAND	10	36	29	15	3
OPPLAND	35	45	17	11	1
OSLO	16	79	68	46	49
ROGALAND	20	54	39	19	12
SOGN OG FJORDANE	13	25	21	7	2
SØR-TRØNDELAG	26	49	31	16	17
TELEMARK	11	31	19	8	3
TROMS	9	33	34	8	6
VEST-AGDER	7	29	16	3	0
VESTFOLD	15	35	19	10	3
ØSTFOLD	15	35	25	10	2
Total	377	782	542	268	144

Source: NIoBE, 2018.

Notes

1 Reduced population as defined above; 112 entities that lacked information about location and/or employment were not included here.

2 Employment classes are based on maximum annual numbers of employees between 2009 and 2016. Micro-firms have fewer than 10 employees, small firms between 10 and 49, medium between 50 and 249, and large over 250 employees. The national VoB database is used (Brønnøysundregistrene), supplemented by the stock-value of the firm and firm type (e.g. sole proprietorships).

about how these different types of actors that are located in different parts of the country actually contribute to innovation in the circular-economy. In the final section, NIoBE is used to target a questionnaire that was directed at firms whose activities appeared to be linked to organic waste streams.

11.3.3 Mapping of innovation in the Norwegian circular economy

In this final empirical section we present the results of a mapping exercise that was carried out in Norway in the spring of 2017 to better understand what firms do to derive value from different organic waste streams. This mapping exercise targeted firm-level activities involving organic waste in the six focal subsectors of the SusValueWaste project: (i) forestry, (ii) aquaculture and seafood processing, (iii) beer brewing, (iv) meat processing, (v) dairy and (vi) organic waste processing. In addition, a seventh category, consisting of

Table 11.4 NIoBE population of bioeconomy entities by sector (NACE) and by type of municipality ($n = 2{,}239$)

	Primary Industry	*Mixed agriculture and manufacturing*	*Manufacturing*	*Less central service industry*	*Less central, mixed service industry and manufacturing*	*Central, mixed service and manufacturing*	*Central service industry*	*Total*
Agriculture, forestry, fishing	77	90	76	78	179	34	87	621
Education, health and other public services	1	1	3	5	12	7	50	79
Manufacture food products and beverages	20	13	16	23	29	19	49	169
Manufacture other	8	15	27	15	56	8	68	197
Non-private services	1	0	2	2	4	2	37	48
Professional, scientific and technical activities	8	8	19	8	50	11	178	282
Utilities, transport and diverse services	39	36	69	88	247	68	296	843

Note
Sectors are classified according to NACE divisions. Classification of municipality groups according to Statistics Norway at the lower level of aggregation of municipalities (‘kommuner’).

R&D-oriented service firms, was also included, echoing our original focus on R&D expenditure described above (an overlap of 14 entities).

The purpose of the exercise was not to perform a representative survey of activity in the circular bioeconomy (cf. Biosmart) but to get a better idea of how biomass and organic waste is used by different entities in different markets. The instrument was therefore addressed to entities in the NIoBE population to increase the likelihood that respondents in fact hosted (or planned) activities involving such organic resources. We go on now to briefly introduce the design of the non-probabilistic sample procedure and of the questionnaire, before finishing by reviewing some of the results. A more in-depth account of the data collection process can be found in a separate report by the TIK Centre at the University of Oslo (Normann, 2018).

11.3.3.1 Approach and population

A questionnaire was used to collect data about the extent and orientation of organic waste activities, the sources of feedstock used, the distribution of innovation in different contexts and other questions such as barriers to innovation activities or the importance of collaboration. In this sense, the instrument modelled some of its questions on items in the Community Innovation Survey (CIS), as well as adding in other questions (about feedstocks, etc.).

The questionnaire consisted of nine sets of questions, including a control question about current activities by type of organic waste. The sections collected information about the types of feedstocks, technology and knowledge sources, drivers and barriers, the importance of public measures, costing and financing relevant activities, collaboration, innovation activities, as well as generic information about the firm. A pilot round was used to calibrate the questionnaire before a new version was sent to a population of 304 entities. The survey was sent by email. The relevant contact points at the individual entities were identified in advance either by accessing publicly available information (website) or by phoning the entity.

A census-type survey approach was applied to collect data in this mapping exercise. Given the noted problems when identifying target firms, data collection utilised the NIoBE dataset (above) as a population frame for the Norwegian circular bioeconomy. The sample for this exercise included about 12% of the total NIOBE data current at the time of sampling. The design for this subpopulation was based on a number of clear criteria. Selection criteria included the following:

1. the entity was a private sector firm;
2. the firm was linked to at least one of the six targeted activities, namely (i) forestry, (ii) aquaculture and seafood processing, (iii) beer brewing, (iv) meat processing, (v) dairy and (vi) organic waste processing; or a seventh category consisting of R&D-oriented service firms;

3 the firm was drawn from the overlapping category of NIoBE (i.e. the subpopulation of bioeconomy actors present in more than one data source); and
4 the firm was not a sole proprietorship and it was registered as active in the underlying databases at the time of the survey.

The sample constituted a full count of entities that fulfilled these criteria in NIoBE. Following an initial drawing of the sample, a round of validation was conducted to exclude defunct or misreported entities (especially in waste processing).

11.3.3.2 Results

The questionnaire, which was sent to the 304 actors, resulted in 133 responses, of which 85 were complete responses confirming ongoing activities in the area (see Normann, 2018). The completed questionnaires provide the main focus of the review presented here. A further 48 reported no current activity and were only asked generic questions, e.g. about unexploited opportunities related to organic waste activities.

Which types of organic waste activities do the companies carry out? Figure 11.1 breaks the population of 85 entities down by size, subsector and the type

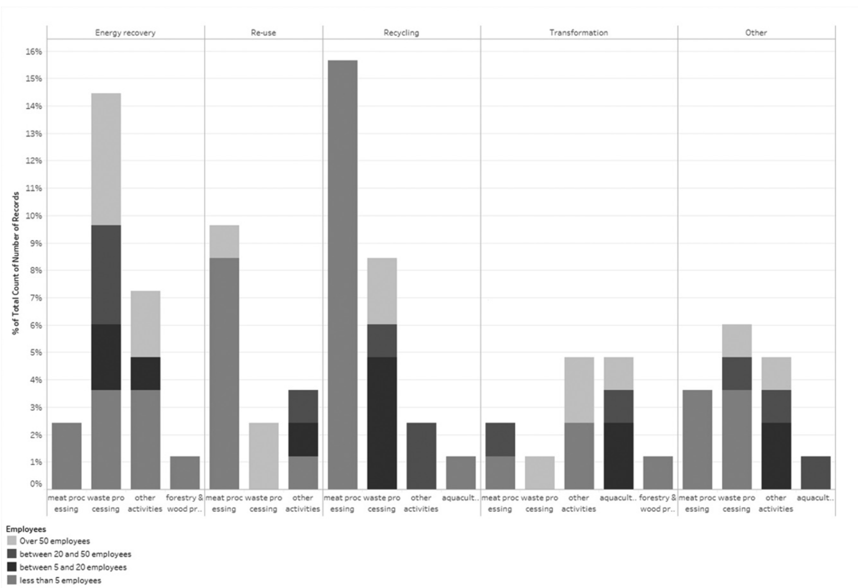

Figure 11.1 TIK questionnaire: 85 respondents by size class, subsector and type of activity.

Source: TIK, 2017, collated by NIFU.

of activity the firm is involved in: the recovery of energy from different organic feedstocks, their re-use or their transformation, as well as recycling or other uses. With more than one type of activity allowed for each respondent, we observed that recycling appeared to be the main activity type, while re-use and transformation, which aim to upgrade to a different type of product, were less frequent. Energy recovery is pursued by 31 firms, i.e. by more than one third of the firms involved in organic waste activities. Simultaneously, we observed the predominance of small firms, not least in the meat-processing area. The waste-processing firms, on the other hand, tend to be larger.

Of the 85 firms that have declared activity connected to organic waste, 64 consider it to be the core activity of the firm, while 21 define it as a supplementary activity. When asked specifically about activities involving transforming bio-based feedstock into new intermediate products, less than half of the firms involved in the activity defined the activity as 'core'. A similar proportion is observed for involvement in the development of new OW technologies to be sold to other companies. In contrast, activities devoted to the development of new products for end users are almost as frequently defined as 'core' as 'supplementary'. An intermediate case is represented by activities of selling and/or delivering to other companies without transformation.

The orientation and intensity of organic waste-oriented activities differ by type. Figure 11.2 demonstrates that the branch of firms involved in recovering energy from organic waste reports that roughly a third of their business activities (and turnover) are related to this activity. The proportion is higher for transformative activities. Noting that the activities might overlap, we see that firms involved in recycling-oriented activities report on average a fourth of their activity in this category.

What is the source of bio-based feedstock? Noting that there may be more than one source, half of the companies responded that their feedstock was produced as a by-product of the company's own production activities. Significantly fewer companies obtained bio-based feedstock from other companies, for free (10) and/or by purchase (14).

Thirty-one firms have invested in R&D linked to its organic waste activities in the last three years. A minority of seven of the 31 firms reported spending more than 80% of the R&D budget on activities related to organic waste. Table 11.5 breaks down the RD&I activity by the share that report R&D expenditure and the share that also report product and/or process innovation. A final category indicates whether the firm has acquired new machinery expressly to process organic waste. The same firm can report multiple types of waste-related activities (e.g. energy recovery and re-use).

Those firms that report ongoing activities in transforming organic waste are the most active innovators in this area. Eighteen firms have introduced and commercialised a new product related to organic waste in the last three years. For most firms, the new products relate to recycling and transformation. Four of the firms have new products related to energy recovery, and

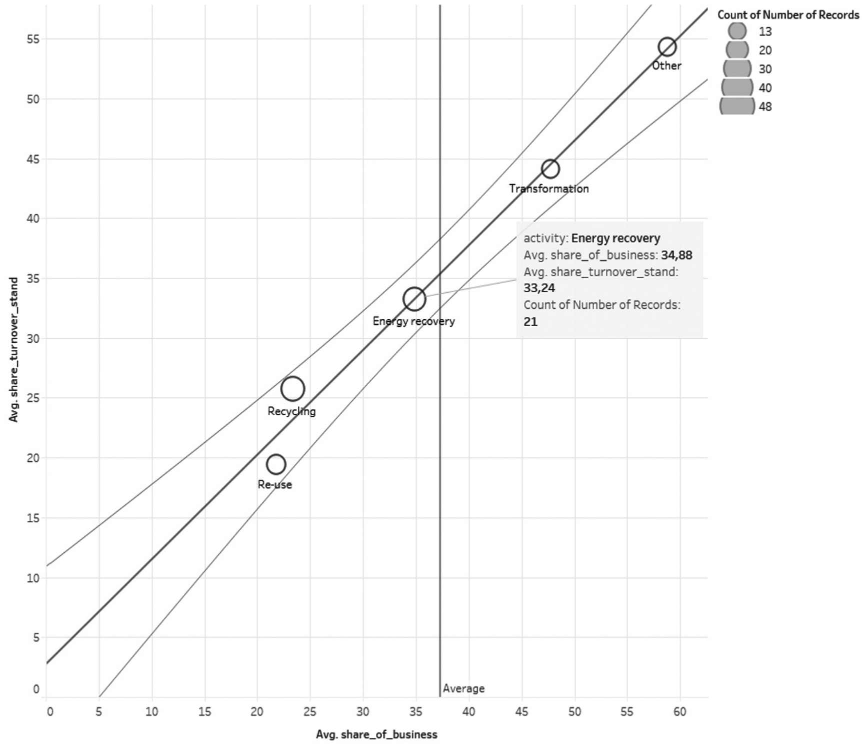

Figure 11.2 TIK questionnaire: 85 respondents by importance of organic waste in terms of share of business activities (x-axis) and turnover (y-axis).

Source: TIK, 2017, collated by NIFU.

Table 11.5 TIK survey: firms reporting R&D investments, reporting R&D or innovation activities, and purchase of machinery to process organic waste: by type of organic waste-related activity

Organic waste-related activity	*Number of firms*	*R&D activity (%)*	*RD&I activity (%)*	*New machines (%)*
Recycling	23	22	39	39
Energy recovery	35	29	33	43
Re-use	22	33	33	33
Transformation	48	77	85	69
Other	59	38	62	31
Average shares	**35**	**36**	**47**	**42**

Source: TIK, 2017.

only two firms have new products related to re-use. On the other hand, 25 firms have introduced a new process related to organic waste in the last three years. Pre-treatment processes and fermentation/biochemical processes are the most frequent, while extraction and separation processes have been introduced by seven firms.

11.4 Preliminary conclusions

There are two preliminary conclusions that can be drawn from our study.

The first one relates to the difficulties of approaching the 'bioeconomy' meta-sector empirically, since even the theoretical definitions of the meta-sector are still evolving within the current scientific literature. When we wanted to target a specific survey about organic waste at the population of Norwegian bioeconomy firms, we faced discrepancies between the theoretical directions which we ideally wanted to explore, and the empirical possibilities we had according to the information available. Indeed, the data sources we looked at, concerning the reconstruction of the population of 'bioeconomy' firms in Norway, were based on firms' innovation inputs and outputs (funded RD&I projects; R&D surveys; patents), on the economic context the firms belong to (industry classification; affiliation to industry networks) and on more subjective judgements made internally by the firm or externally by experts (self-identification vs. supervised reviews). In order to cover the different conceptual approaches to the bioeconomy meta-sector, researchers need to navigate through the available data sources and make a series of decisions about how to intersect or merge different data layers, each of which connects to one or more theoretical approaches to the bioeconomy.

A second conclusion relates to the specific role of organic waste activities within bioeconomy firms. On the one hand, organic waste activities are often core activities, thus constituting a distinctive characteristic of a firm. On the other hand, the development of new products related to organic waste is not a central concern for such firms. Moreover, unless there is waste transformation involved, the activities related to organic waste seem to attract a low share of the firms' total R&D budget. Therefore, in order to reach out to firms who actively seek to realise value from organic waste streams, an identification based solely on RD&I indicators may not be sufficient. R&D&I data sources can provide an important first indication of organic waste activities, e.g. by highlighting R&D allocated to the areas of 'circular economy' and 'ecology', or by recording patents on biological treatment of waste (CPC class 'Y02W'). However, complementary sources, such as trade descriptions in financial data or self-identification in response to specific survey questions, can become necessary to detect other relevant firms, whose active role in organic waste activities may not be supplemented by corresponding activities in research and innovation.

Note

1 This section is based on earlier background work reported in Iversen (2016) and Iversen and Rørstad (2017).

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