Erasmus Universiteit Rotterdam
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MSc Urban, Port and Transport Economics

The bio-based cluster in the Flemish-Dutch port Delta

What is the location, size and growth and how can its performance be measured?

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Preface

As a student, the thesis is something that looks up front like a big hurdle. And indeed, it does take quite some time and a considerable amount of effort before you can actually hand it in. However, once you have an interesting and challenging subject, it becomes actually very satisfying when a new result comes out or when a chapter is finished. The bio-based economy is something that I had not really heard of before, but it proved to be an interesting and very relevant topic. I have found it great to learn about current developments and entrepreneurial companies that someday might influence the new way in which we organise our economy. Now, it has taken long enough and I am pleased to conclude this part of my academic career.

Choosing the MSc in Urban, Port and Transport Economics seemed a logical choice about a year ago, as it had been one of the reasons why I chose to study at the Erasmus University Rotterdam. Having always been interested in geography and economics, this seemed like the ultimate combination. Along the way, I have also become interested in other aspects of the economy and business life. Therefore, I will continue my studies here by following an MSc in Finance and Investments. My graduation will then hopefully follow somewhere around this time next year.

I would like to thank the staff of RHV / teachers of Urban, Port and Transport Economics for the interesting subjects they offered us students last year and I can definitely recommend the programme to any other student. Special thanks go to Martijn van der Horst, for his patience and structured way of helping me in writing this thesis, my friends and housemates for making this summer still a fun and enjoyable one and finally my parents, for supporting me all the way up to this point.

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1. Introduction

"Business doesn't have to choose between making profit and protecting the environment, between economic success and ethical responsibility, between satisfying the customer and meeting the demands of other stakeholders. In other words, we don't have to make a choice between profits and principles." – Jeroen van der Veer, former CEO of Royal Dutch Shell and current ambassador of the Biobased Delta

According to many scientists, politicians and other experts in the field, the way we currently use the earth's natural resources is unsustainable in the long run, both for the environment and because of a depleting stock. By being largely dependent on fossil fuels for our economy, four major challenges lie at the heart of the sustainability problem (GEA, 2012):

– Soaring greenhouse gas emissions

– Decreasing energy security

– Air pollution at the local and regional levels with resulting health problems

– Lack of universal access to energy services

It is this awareness that has spurred research and development programmes in order to find alternatives for fossil fuels such as natural gas or oil. One of those developments is the rising importance of biomass as an input in energy or chemical production processes. So-called bio-based activities are increasingly used as an alternative for polluting or non-renewable resources. By using mainly agro feedstock, a more sustainable way of production can be achieved without depleting some of the world's natural resources. In the world, more and more industrial companies are experimenting with the implementation of these new techniques. This will be discussed in the next paragraphs.

1.1. Ports as places for industrial activities moving towards a bio-based economy

Ports have traditionally been places where cargo is stored and further distributed towards its final destination. Over the years, many ports across the world have evolved from these cargo handling and transhipment places into larger port areas where many services, production and other activities take place. The types of activity are often related to traditional sectors such as the oil, gas and petrochemical industry. However, developments in the field of sustainability and environmental impacts have caused new operational challenges for seaports. For example, the Rotterdam Port Authority names CSR as an important feature for the port authority: "The Port of Rotterdam Authority regards Corporate Social Responsibility

(CSR) as the key to a successful future" (PoR, 2013). This is a trend that can be seen in other European seaports as well.

Here lies a challenge for the Flemish-Dutch port region, which includes two of the largest ports in the world. In order to compete with other industrial centres worldwide, there is increased co-operation between ports within this delta region. This is also indicated by Vanelslander et al. (2011), stating that seaports in the Flemish-Dutch port Delta should combine forces in competing with other petrochemical clusters on the world level. While this industry is currently in a transition phase towards cleaner production processes, this provides an opportunity for the Delta region for obtaining a leading role in this development.

1.1.1. The bio-based economy defined

Within the European Union, including countries such as the Netherlands and Belgium, there is a clear trend towards an increased use of bio-products in the process of energy and chemical production. The notion often used to describe this development is the "bio-based economy" (BBE). The European Commission definition of the bio economy (BE) is "the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy" (European Commission, 2012). The Centre for Biobased Economy (CBBE), one of the leading Dutch institutions in the field, defines the bio-based economy as "an economy where green resources are used to sustainably produce non-food products, both end-products as well as inputs or additives" (CBBE, 2013). Vandermeulen et al. (2011) define in their paper on the size of the Flemish bio-based industry the bio-based economy as "an economy for which all inputs come from renewable sources". They argue that despite this theoretical concept of the bio-based economy, large differences persist in what the term actually entails. One can imagine that the size of the bio-based economy is relatively small when the term is read as 100% bio-based activities compared to bio-based initiatives that only promote the initial steps towards full usage. One can also separate between traditional biomass applications, such as feedstock for agriculture and food production, and new applications such as the use of biomass in co-fired power plants or the manufacturing of chemical products.

Vandermeulen's definition is very broad as she self already says. Therefore, it is not very appropriate to use her definition in this paper. Another distinction that she mentions is about the use of biomass as an input (traditional vs. non-traditional). This explains exactly the difference between the other two abovementioned definitions (BE vs. BBE). For example, one can read that in the second definition (CBBE), food products made from biomass are explicitly excluded. The reason for this is that food is a traditional application of bio-based inputs, whereas with the "bio-based" economy especially non-traditional production

processes are relevant. The term bio-economy (BE) does include the food component, however bio-based does not. Therefore, the CBBE definition is used throughout the remainder of this paper.

Vandermeulen et al. (2011) distinguish two important sectors of the bio-based economy: bio-based energy and bio-based products (table 1). Bio-based energy comprises not only electricity production from biomass, but also bio-based heat and the production of biofuels. Bio-based products are either different types of materials or chemicals. Traditionally, bio-based products have received less attention than bio-energy but currently specific policies are also aimed at R&D for bio-based products.

Table 1: The bio-based economy in Flanders

Sectors	Gross margin		Employment	
	X10^6 €	**%**	**FLE**	**%**
Bio-based energy				
Bio-based gas	38	3.4%	374	4.0%
Bio-based electricity	89	8.0%	456	4.9%
Bio-based heat	210	18.8%	842	9.0%
Bio-based fuels	25	2.2%	146	1.6%
Sum	325	29.4%	1444	15.4%
Bio-based products				
Paper	215	19.3%	1546	16.5%
FIberboards	256	22.9%	1991	21.3%
Biobased plastics	52	4.7%	847	9.1%
Biobased chemicals	268	24.0%	3532	37.7%
Sum	791	70.9%	7916	84.6%
Total bio-based economy	1116	100.0%	9361	100.0%
Total Flemish economy	60,949		2,585,296	
Percentage bio-based	1.8%		0.4%	

Source: Vandermeulen et al., 2011

1.1.2. Policy initiatives for the bio-based economy

Currently, much policy concerning the promotion and stimulation of 'bio' resources in production processes is being implemented. For example the Horizon 2020 project, the European programme for Research and Innovation, deals primarily with European sustainability issues (European Commission, 2011). This means that specific policies but

also large subsidies are available for European scientific research in ‘sustainable development’, both for academia as well as the industry.

Following the developments at the European level, both governments of the Netherlands and Belgium have also developed more interest in promoting the bio-based economy. The Dutch ministry of Economic Affairs, Agriculture and Innovation (via Agentschap NL) has taken the lead in developing a combined strategy about the role and importance of the bio-based economy in the Netherlands, ahead of several other ministries and governmental departments (Agentschap NL, 2013). Agentschap NL acknowledges the leading position of the Netherlands in agro-logistics and international trade together with the presence of an industrial seaport region as important assets in developing a bio-based economy. In Belgium, the Flemish government is also increasingly promoting the concept of the bio-based economy but much policy has been focused on the development of bio-energy rather than bio-based products. A lack of R&D and pressure of the European Union were identified as the main causes for this underdevelopment in production (Clever Consult, 2012).

At a regional level, there have been many initiatives around the theme ‘bio-based economy’ in both Flanders and the Netherlands. Especially the northern part of the Netherlands as well as the region south-west Netherlands – north-west Flanders host a number of firms and institutions related to the bio(-based) economy. In the Delta region, one will encounter that many initiatives are located in between the large seaports.

1.1.3. The Flemish-Dutch port Delta

In this paper a specific focus will be placed on the Flemish-Dutch port Delta, a region that embodies two of the largest seaport clusters in the world. The ports of Antwerp and Rotterdam have been important engines of both countries’ economies over the last years and are important trade hubs for whole of Europe. In the combined port Delta, different industries and clusters have developed over the years. Good examples are the logistics hub near Breda or the (petro)-chemicals cluster in the Antwerp port area.

Apart from regional initiatives described earlier, one can also identify developments on the port level. Port authorities in both countries have also included the development of a bio-based industry in their corporate strategies, which means that both strive to increase the share of this industry in their port regions in the coming years. In Port Vision 2030, a strategy document of the Port of Rotterdam, the need to use cleaner forms of energy such as LNG, biomass or solar power is acknowledged. Regarding chemical products it is stated that “In 2030, Rotterdam will be a premier location, where the transition to bio-based chemicals is in full swing”. In addition, the port authority has about 200 acres destined on the Second Maasvlakte for new business developments in the bio-based sector (PoR, 2013). Similar

steps have been taken in Belgium, where the port of Ghent functions as the main hub for biomass and R&D in the bio-based industry (Biopact, 2006). The Antwerp Port Authority addresses the sustainability issue too, but is less detailed on the role of bio-based production (Port of Antwerp, 2013). In research covering the combined ports as a delta, Vanelslander et al. (2011) write that they see the transition of the local Industrial Cluster towards a "world-class bio-based cluster" as one of the main forces for the near future.

1.2. Measuring the performance of the Flemish-Dutch port Delta bio-based cluster

Now, we have identified some of the characteristics of the bio-based economy and current developments in the field of policy initiatives. In addition, a short overview of the Flemish-Dutch port Delta was provided, as a geographic area where many of these bio-based activities are concentrated. The relevance and need for performance measurement of this specific region now becomes more evident.

1.2.1. Relevance

As has been stated earlier, the importance of the bio-based economy as both an opportunity and a necessity is recognised at different management and governmental levels. For example, this holds not only at the level of the European institutions, but also for the Dutch and Flemish governments. When assessing the regional initiatives in the bio-based field, one can link this to the importance of the Delta. The Flemish-Dutch port Delta is a region in which multiple initiatives occur related to the bio-based economy. From R&D towards local manufacturing, the region boasts a large concentration and variety of firms.

In examining the bio-based cluster in the Flemish-Dutch port Delta, one should be interested in measuring the current performance of the cluster as a whole. In order to do this, a number of key cluster performance indicators will be necessary and need to be identified. De Langen et al. (2007) state that it is mainly due to the complexity of the notion of 'the port' and its complex 'products' that it has been difficult to find an appropriate set of performance indicators. In academic literature, there has been a gap in research on port's industrial clusters and how to measure their performance. In fact, much research has been performed on seaports in their role as a transport node by measuring e.g. throughput volume. One of the early studies on the wider economic function of seaports has been performed by Haezendonck (2001), who calculated the value added that is generated in the wider port region.

1.2.2. Research question

In this paper, a number of performance indicators will be assessed on their relevance in relation to the Flemish-Dutch bio-based cluster. These indicators will be generated from

earlier work by other scholars and also indicators based on more specific characteristics of this new industry will be included.

The research question of this paper is:

- *What is the location, size and growth of the bio-based cluster in the Flemish-Dutch port Delta and how can its performance be measured?*

This question can be further divided into the following sub-questions:

- *S1: How do (industrial) clusters function and what are relevant performance indicators for measuring the performance of a bio-based cluster?*

In order to answer this question, an overview of the scientific contributions in the field of clusters and cluster performance will be provided. In addition, a number of key performance indicators will be identified which will be assessed based on their relevance. This assessment is based on an extensive overview of existing literature.

- *S2: What are the functional and geographical boundaries of the bio-based cluster in the Flemish-Dutch port Delta?*

These boundaries will have to be determined in order to clearly define the scope of this research. The functional boundaries are directly related to the bio-based industry and its functioning. In this part, the geographic boundaries will be explained by following the existing definition.

- *S3: Where is the bio-based cluster located in the Delta?*
- *S4: What is the current size of the bio-based cluster in the Delta?*
- *S5: What is the growth of the bio-based cluster in the Delta?*

These three questions are each part of the overall research question. They will be answered based on empirical research using a self-constructed database. For each sub-question, specific performance indicators have been selected that are most suitable for the analysis. The results are analysed in Excel using a.o. the input from company- and regional databases.

1.2.3. Outline

For answering these questions, this paper has been structured as follows. Part 2 accounts for the results on the first sub-question, by describing the functioning of clusters and relevant performance indicators. In part 3, the boundaries to the bio-based cluster in the Delta will be explored. In addition, the origin and availability of the data is explained in detail. Part 4 will comprise the analysis that is needed for answering the remaining questions. Finally, part 5

will include the conclusions and provide the reader with some recommendations for future research.

2. Literature review: Towards a set of performance indicators

In describing the functioning and performance of the bio-based cluster in the Flemish-Dutch port Delta, it is necessary to first start with an overview of existing literature in the field of industrial clusters in port deltas. A further definition of the bio-based economy and more specifically, its location and boundaries, will be discussed in part 3.

The first sub-question of this paper will be addressed by means of the following steps. First, the issue of performance measurement in ports is addressed and at what levels this can be done. Second, theories based around clusters provide a framework through which the bio-based industry in the Flemish-Dutch Delta can be analysed. Finally, key indicators for cluster performance are identified and explained. After this chapter, the reader will have a better understanding of performance measurement for industrial clusters in general and seaport's clusters in particular.

2.1. Measuring port performance

Port performance can be measured for different 'products' at different levels, for example from a firm, sector or macro perspective. De Langen et al. (2012) identify three different products ports can provide; the cargo handling product, the logistics product and the port manufacturing product. This paper only focuses on the latter product, as cargo and logistics are just additional services in the case of the bio-based cluster. When the performance of industrial activities increases, in addition cargo handling and logistic activities for these sectors will also flourish.

As has been mentioned, performance and competition can be measured at different levels. In cargo handling, much competition is locally based between different ports in a region. Competition between ports in this field can take place on the basis of their captive and contestable hinterland (OECD, 2011). Ports that have a larger captive hinterland (in terms of relative accessibility) have a competitive advantage over other ports. Competition increases when this cost advantage is lower and the hinterland is accessible from many different ports.

Whereas the competitive playing field of ports with respect to e.g. cargo handling is mainly between ports in the same port range (e.g. the Hamburg-Le Havre range in the case of Rotterdam), the competition for industrial activities often takes place at the global level. In the case of the petro-chemical industry, important hubs world-wide are located in Houston, Singapore, Rotterdam, Antwerp and Abu Dhabi (Roland Berger, 2012). These ports provide space for different kind of industrial (chemical) companies looking for cluster benefits. These cluster benefits will be explained in more detail in the following sections.

2.2. The cluster concept in theory

Probably the most famous example of a cluster is Silicon Valley in California, a region that incorporates some of the largest internet and computer companies in the world. Among its success factors are primarily the nearby academic expertise of Stanford University, a well-willing government and the attractiveness to be located near other high-tech companies. Kenny and von Burg (1999) made a comparison between Silicon Valley and another US IT cluster (Route 128, Boston MA) in terms of performance and growth over recent decades. They find that the success of Silicon Valley is mainly attributable to its ability to feed incumbent companies and their spin-offs with opportunities and to create an ever-going loop of relationships between new firms and existing ones. Therefore, it is regarded to be the prime example in the world of clusters and cluster theory.

2.2.1. Definition

Cluster theory has been widely used in academic literature to explain phenomena related to the co-location of different firms in a geographically proximate area. Porter (1990), as one of the first in the field, explained in his book 'the Competitive Advantage of Nations' clusters as "a spatially concentrated group of firms competing in the same or related industries that are linked through vertical and horizontal relationships". More recent academic research on clusters related to seaports by De Langen (2004) defines the concept as follows: "A population of geographically concentrated and mutually related business units, associations and public (-private) organizations centred around a distinctive economic specialization".

For completeness, the second definition is used throughout this paper for further analysing the cluster in the Rhine-Scheldt delta. The term population is used by de Langen (2004) to indicate the dynamics of a cluster, with the in- and outflow of different companies over time. Furthermore, he specifies that we are dealing with not just firms, but also subsidiaries of MNE's for example. This is important as many of the world's largest corporations (financial institutions, tech-firms etc.) often appear to be located relatively close to their peers in different parts of the world.

The matter of geographic concentration has been found to be particularly difficult as there are again different definitions possible in this case. For example, one can think of measurement in terms of a certain distance from a theoretical gravity point. Another viewpoint might be in terms of relevant links among companies, which will ultimately result in a relevant geographic distance. Bathelt et al. (2004) argue that strong clusters are closely located because of the easy transfer of tacit knowledge. To what extent this leads to determining geographic boundaries remains a matter of debate. Later in this paper, explicit attention will be paid to the geographic boundaries of the cluster in this case.

Business units, associations and public (-private) organizations are especially useful as a means of an analysis in the regional setting of a seaport. Business units can be part of a larger (multinational) company, but are necessary to include in the analysis even though they might only be a small part of the firm. Public (-private) entities play an important role in developing, stimulating and maintaining new developments, e.g. in the case of environmentally friendly technologies. Another important aspect is that firms should be mutually related to each other, either as complements or as competitors in the same field.

A cluster should be concentrated around a distinctive economic sector, e.g. in the case of the movie industry in Hollywood or the biotech cluster in Cambridge (Silicon Fen). However, here one arrives at yet another difficulty in determining a cluster as there is often overlap of different sectors. Again, later in this paper more focus will be given on the functional boundaries of our particular cluster.

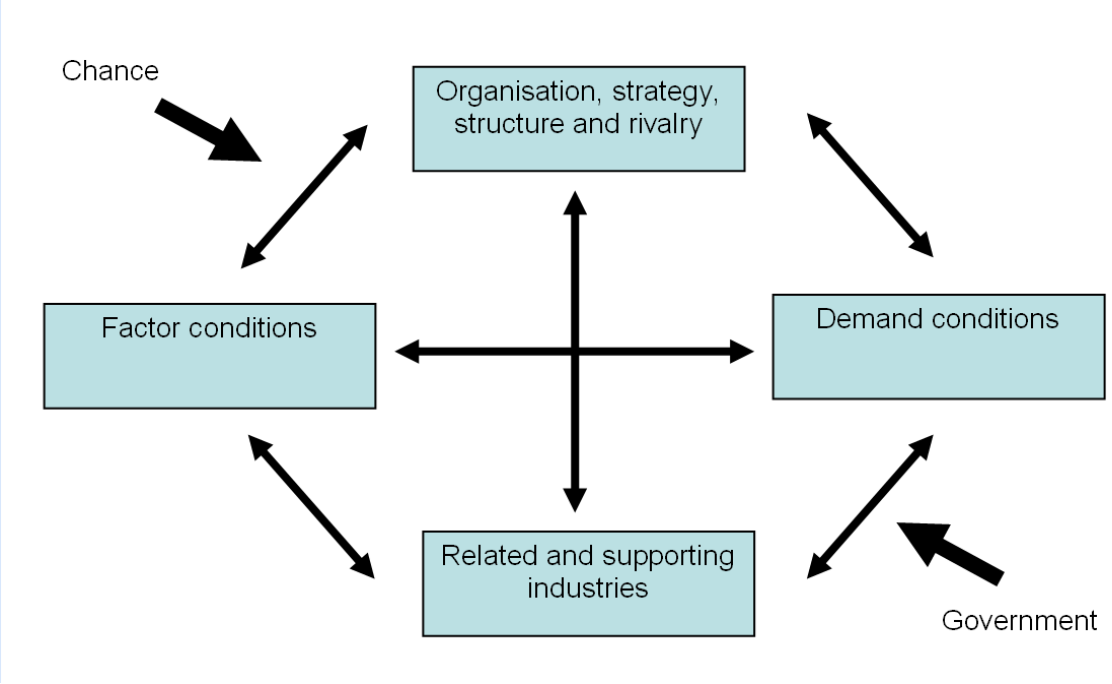
2.2.2. Cluster theory

The theory on clusters has been an important tool in economic and geographic research. Much of the theory is based on the early work of Marshall (1920) on agglomeration economies. These economies can be seen as one of the main location benefits. Agglomeration economies will be dealt with in more depth later in this part.

Porter has often been named as one of the first scholars to formulate a theory based on clusters and their role in the economy, based on his Diamond model. Porter (1990) explained in 'the Competitive Advantage of Nations' some reasons for the performance of certain industries and the role that countries and their governments can take to enhance this. He does so by schematically assessing 4 important factors in a diamond pattern (figure 1).

- Factors Conditions
- Demand Conditions
- Firm Strategy, Structure and Rivalry
- Related and Supporting Industries

Figure 1: Porter's Diamond Model



Source: Porter (1990), The Competitive Advantage of Nations

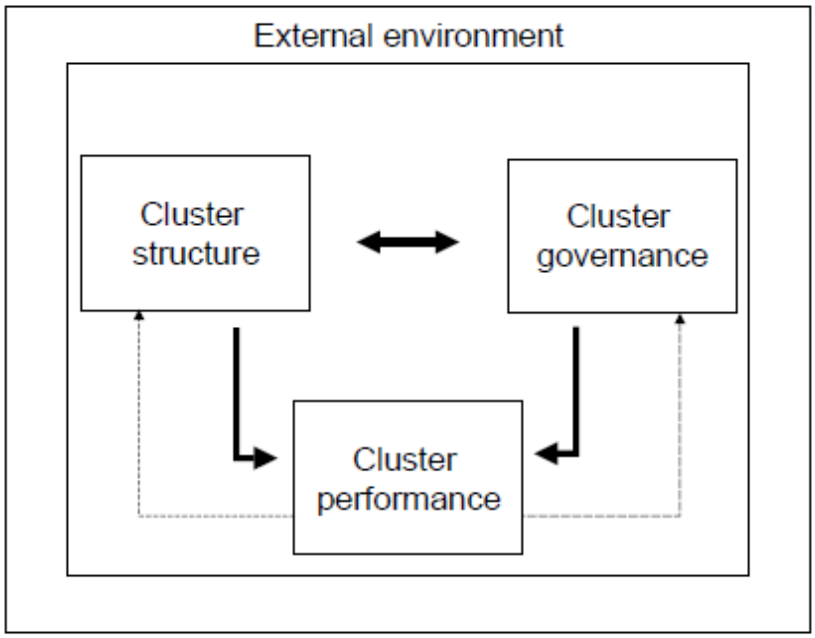
Based on this diamond scheme, Porter states that the existence of clusters is fostered by the environment in which these factors operate. Clusters are formed by groups of companies in competitive industries through horizontal (e.g. similar client base) and vertical relationships (e.g. buyer-seller). A cluster may provide benefits which should keep the industry as a whole competitive in relation to other countries.

There exists also criticism among many academics, mainly economists, on the work of Porter and the Diamond School. Although Porter's theory provides valuable insights in factors influencing the functioning of a cluster, it also lacks a solid theoretical base according to De Langen (2004). For example, Krugman focuses more on the effect of agglomeration rather than explaining the rise and fall of individual clusters.

Specific literature based on the functioning and performance of seaport clusters has mainly been provided by De Langen (2004). He summarizes a number of general theories, e.g. Porter and Krugman, and introduces a new overview to place a number of cluster characteristics in a new framework. He identifies the notions of 'cluster structure' and 'cluster governance' as key influential features of the overall performance of the cluster (figure 2). Cluster structure entails a number of elements that have a direct link with performance indicators. This means that the theory behind these factors is easily connected to 'measurable' or quantifiable terms. The governance of a cluster relates to "the coordination

of activities in a cluster". Coordination can be organised in different ways ('make-or-buy decisions') and at different levels such as at firm- or industry level (Williamson, 1985).

Figure 2: De Langen's model on cluster performance



Cluster performance	
Cluster structure	**Cluster governance**
- Agglomeration effects - Internal competition - Cluster barriers - Heterogeneity	- Presence of intermediaries - Level of trust - Embedded leader firms - Solutions to collective action problems

Source: De Langen (2004), The Performance of Seaport Clusters

2.3. Cluster performance

It is necessary to define what we mean by cluster performance in order to analyse the bio-based cluster in the Dutch Flemish port Delta. Issues that may arise when measuring the performances of industrial clusters are shortly addressed before appropriate indicators are proposed later in this chapter.

Probably, one of the first issues is related to the question: how to measure performance? In this paper, evidence and results of earlier work on specific indicators by other academics is used to analyse the performance of the bio-based cluster. A universal set of indicators that are appropriate for the type of industry can then be used to compare different clusters. The

usefulness of certain indicators may differ from case to case and is dependent on the nature of the industry (e.g. high-tech or more traditional). Furthermore, there are different views on the exact benefits of a number of these variables. Examples such as cluster size and diversity are explained below.

From the literature we know that many scholars have written about measuring cluster performance and the influence of diversity. When taking a macro-approach, one can argue whether regions should specialize and focus on specific industrial clusters as diversity might also entail additional economic benefits. Porter (2003) identifies two schools of thought with respect to this debate. He argues that Glaeser is an example of a strong proposer of the specialization case (Glaeser et al., 1991), through which long-term average costs are expected to decrease at a higher rate because of learning effects. Jacobs (1969), on the other hand, has argued that innovation and creativity are fuelled by a diverse range of industries.

Despite the debate about cluster diversity displayed above, Porter (2003) has stated that regional economic performance strongly depends on the individual performance of clusters and innovation. In relation, he argues that economic policies should be developed at the regional level rather than for the entire country as there are noteworthy differences in productivity, innovation and thus competitive advantage.

Then, there is also the issue of appropriate cluster size. Folta et al. (2006) found empirical evidence for decreasing returns to scale for agglomeration benefits of clusters. Up until a certain size, cluster benefits arise because of patenting, alliances and credit availability but at one point the marginal benefits become smaller than the marginal costs of being located in a cluster. A possible explanation could be that the performance threshold becomes higher in larger clusters, which might give rise to entrepreneurs or managers in losing firms switching to other business opportunities.

A final example can be found in the growth dynamics of a cluster. It can be argued that the influence of high fluctuations in the number of firms present in the cluster differs per industry. For example, De Langen (2004) describes two important determinants of the value contribution of a cluster, the incumbent performance effect and the population effect. The first effect is caused by the current firms and their performance. The population effect is mainly existent in clusters with mainly intangible assets, which means that companies and start-ups make their way easier in and out of business. In the remaining part of this chapter, one will observe a number of performance indicators followed by an assessment of their respective (dis)advantages and appropriateness.

2.4. Performance indicators

In this paragraph, a number of possible measures are discussed in order to estimate the performance of the bio-based cluster as a whole. Some of these performance indicators will later be used to analyse the size and growth of the bio-based cluster in the Flemish-Dutch port Delta. When assessing earlier contributions in this field, one will encounter that there is still a debate in academic research with respect to right indicators for performance measurement. De Langen et al. (2007) argue that one of the main reasons in the case of seaports is the complexity of the port with different firms, users and functions. This section will discuss some more traditional indicators as well as some new ones used in specific industries.

2.4.1. Different performance measures

When one wants to examine the performance of a certain industry, or in this case a regional set of companies within the same industry, very often financial measurements are the first to be used. For example as de Langen et al. (2007) show, this is also the case in ports where one can find a number of (financially related) indicators in the port authority's reports such as throughput volume or value added. One should realize, however, that the performance of the port authority differs from the performance of a seaport's industrial cluster. The latter is only a part of the total range of port activities, which also includes cargo transfer and logistics.

Furthermore, using mainly financial indicators seems not appropriate for every case. For example, some innovative or high-tech industries might have to grow larger in the future to become financially successful (Folta et al. 2006). This can be caused by a lengthy R&D process, long time-to-market for certain products, regulation and procedures concerned with patenting. In the review below, some focus is therefore also placed on non-financial variables. An overview of the main characteristics of each performance indicator can be found in table 2.

Table 2: Overview of performance indicators for a bio-based cluster

Performance indicator	Description	SMART-indicator ?	Publications
(Average) profitability	+ Well-known term - No clear relationship	+/-	De Langen (2004), Porter (1990)
Productivity and value added	+ Positive relationship - Not always corrected for population size and difficult to measure	-	Porter (1998, 2000), Madsen et al. (2004), De Langen (2004)
Share of exports	+ Supported by theory - No straight-forward evidence in practice	-	De Langen (2004), Porter (1990), Birkinshaw and Hood (2000), Isaksen (1997)
Foreign Direct Investment (FDI)	+ Inward FDI positive effect - Holds only with other 'success' factors in place	+/-	De Langen (2004), O'Malley and O'Gorman (2001), Markusen and Venables (1999), De Propis and Driffield (2006)
Labour: wages and employment	+ Wage levels and labour mobility are clearly related to clusters - Effect of employment is ambiguous	+/-	Porter (2003), Bönte (2004), Power and Lundmark (2004)
Innovation and patenting	+ Innovation and patents good indicators for successful clusters - Difficult to measure innovation (other than patents)	+	Baptista and Swann (1998), Audretsch and Feldman (1996), Porter (1990; 2000; 2003)
New business formation	+ Important attribute for cluster performance - Difficult to single-out the effect of entrepreneurship	+	Audretsch and Keilbach (2008), Glaeser et al. (1991), Feldman and Francis (2004), Feldman et al. (2005), Delgado et al. (2010)
Survival	+ Survival rates seem positively related with cluster strength - Contrasting literature on cluster dynamics	+/-	Delgado et al. (2010), Wennberg and Lindqvist (2010), De Langen (2004), Folta et al. (2006)
Acquiring capital	+ (Venture) capital very relevant for SME's in bio-tech/bio-based sector - Arbitrary to measure in exact terms	+/-	Folta et al. (2006), Mason et al. (2002)
Cluster heterogeneity	+ Important notion in cluster theory - No straight-forward and conclusive evidence	+/-	Shaver and Flyer (2000), Brenner (2005), De Langen (2004)

(Average) profitability

(Average) profitability has often been mentioned as a performance indicator, but it appears a difficult measure as the direct link between being located in a cluster and profits is not yet supported by clear evidence.

Advocates of cluster theory believe that it is mainly due to agglomeration economies that firms located within a successful cluster boast higher profits. Mainly based on the theory of Alfred Marshall (1920), agglomeration economies in clusters arise as "external economies" and occur when multiple firms are located closely to each other. For example, information and knowledge spill-overs may arise from being located in the same cluster. Storper and Venables (2004) first described the notion of "buzz", which they explain as the concept of transferring tacit knowledge through face-to-face contact. Especially, when knowledge is tacit and also fluid as in the case of e.g. technology or financial services, the benefits from localization economies through buzz are substantial.

On the other hand, earlier research also suggests that internal competition between firms within a cluster is one of the conditions for good cluster performance overall; hence a high average profitability does not necessarily lead to a more prosperous cluster (Porter, 1990).

Productivity and value added

Porter (1998, 2000) states that *productivity* increases for companies located in a cluster. There are a number of reasons for this, ranging from inter-firm coordination to improved institutions and the availability of inputs. The shared use of inputs and a similar customer base accounts for specialization and lower transaction costs. This can be realised by having several suppliers upstream and customers downstream or by specialization among competitors. Both have a positive effect on cluster performance as transaction costs will be lower and companies will continue to improve their (specialized) product. Madsen et al. (2004) find empirical evidence for a number of industrial clusters in Denmark that being located in such a cluster entails a significantly higher level of productivity.

While productivity is in many cases seen as a good proxy for economic performance, in the case of clusters some ambiguity might arise. De Langen (2004) argues that a cluster with a declining population can still have the same overall productivity compared to a cluster with more firms, while in fact it is lacking in terms of performance as measured by population growth.

One might argue that the difference between *value added* and productivity is relatively small and is mainly based on distinguishing between firm and cluster performance level. De Langen (2004) finds value added an appropriate measure for cluster performance, as

measured by the total added value of the cluster members. In order to use it in the right way, it is argued to use the future added value but this variable cannot be calculated in practice. The key argument used is that one should use a time-series as to exclude yearly changing effects.

Goss and Vozikis (1994) did research in the field of productivity and high-tech firms. They found that the value added per worker is higher for high-tech firms in locations where many other high-tech firms are present. They also found that having many small firms is more beneficial than only a few larger firms, as the productivity per worker is higher in these small firms. The third result is that high-tech firms boast a higher value added per worker in densely populated areas. This is probably the result of the importance of labour as a production factor.

Share of exports

The *share of exports* as an indicator for cluster performance is primarily related to Porter's Diamond of National Advantage (Porter, 1990). Each of the 4 attributes contributes to the competitive edge of a nation, but as said this concept can also be used at the cluster level. Assets such as a qualified labour pool or a good supplier base are other examples of the requirements in order for a cluster to be successful.

According to De Langen (2004), measuring the trend in the share of exports is not a complete measure for cluster performance as it could be that some of the buying (downstream) firms have moved to the cluster itself. If that is the case, then it logically follows that the amount of exports from the cluster is lower.

Birkinshaw and Hood (2000) examined the characteristics of foreign subsidiaries in 'leading edge industry clusters', for which they used clusters that have a share of world cluster exports double the size of the country average. E.g. if the Netherlands has a 1% share of world exports, then only industrial clusters that have a 2% share of world cluster exports will be taken into account. They argue that there are two major limitations to using the share of exports in determining which clusters have a "leading edge". First, it should be noted that Porter uses country export data whereas agglomeration externalities typically apply at a regional or local scale. Second, they find that the level of exports is not a complete measure for performance.

In addition, Isaksen (1997) studied the link between competitiveness, clusters and the level of exports in Norway. Although he finds that many of the successful and exporting industries are located in clusters, he does not find thorough evidence on how a cluster becomes competitive as measured by the share of exports.

Foreign Direct Investment

When describing *Foreign Direct Investment* (FDI), one can distinguish between *inward* and *outward* direct investment. De Langen (2004) finds inward direct investment a suitable way of measuring cluster performance, whereas the opposite is only an outflow of investments. O'Malley and O'Gorman (2001) found that in the case of the Irish software industry FDI played an important role in the successful development, next to the four conditions of Porter's Diamond framework. They argue that the presence of subsidiaries of transnational companies has contributed in several different ways. Typically, high-tech jobs were provided at these branches or they functioned as business partners or customers.

Other scholars have also done research in the direction of inward FDI on agglomerations, but there has not been much evidence that these streams generate growing clusters. Markusen and Venables (1999) showed that cluster development may arise as a result of multinational linkages. De Propis and Driffield (2006), however, state that attracting FDI might bring along subsidiaries of MNE's and accompanying technologies, it is not said that these investments are actually enhancing cluster performance or are only the basis for a single-firm supplier base (monopsony). Therefore, a link between the level of FDI and the performance of a cluster is not fully supported by the literature.

Labour: wages and employment

Based on Marshall's theory on agglomeration economies (1920), one can argue that when similar types of firms are concentrated in the same area, this will attract a larger labour force to the region. This in turn will lead to lower costs for the different firms within the region, as search costs go down and firing employees becomes easier. This is also in line with Porter's Diamond (1990), which states that regional competitiveness is strongly related to the presence of factor conditions, such as a qualified labour pool.

Porter (2003) examined differences in economic performance across US regions and also compared clusters in the same study. He calls average wages "the most basic measure of its (a region's) economic performance". Wage growth is not significantly related with the starting wage level, indicating that other factors play a role here. Porter finds evidence that regional differences in cluster performance are positively related with different wage levels.

According to Porter (2003), employment growth is said to be weakly related to wage growth, which indicates that regions or clusters with a growing economic function have a growing number of jobs and higher salaries. Bönte (2004), however, finds in a case study of a German industrial cluster that there are no significant differences between employment growth in clusters and in other regions. The effect of employment growth remains thus somewhat ambiguous. A possible explanation could be that some clusters might be using

few employees, for example in high-tech industries. This is especially important to acknowledge when comparing clusters across different industries.

As has been stated, hiring and firing often becomes easier for employers when there are more available workers. On the contrary, for workers it is sometimes much easier to switch between different employers. Power and Lundmark (2004) found empirical evidence that labour mobility is indeed significantly higher in clusters than in the rest of the urban economy. This supports the aforementioned theories and thus the fact that clusters entail different dynamics than other industrial settings.

Innovation and patenting

Innovation is an often heard argument and an important attribute of cluster theory as it has been brought forward by many early scholars in the field (Porter, 1990; Baptista and Swann, 1998). This aspect is generally seen as the outcome of the earlier mentioned knowledge spill-overs and buzz. Especially high-tech and very innovative research is more easily transferable through local connections than over larger distances, hence the benefit of an industrial cluster. This is also supported by Audretsch and Feldman (1996), who found that the degree of 'innovative activity to cluster' is primarily determined by whether knowledge-spillovers occur. In this case, R&D and qualified labour are important attributes of possible knowledge externalities. They find less evidence for the importance of geographic proximity of production, which indicates that innovation is primarily a product of knowledge industries.

In a different paper, Porter (2000) underlines the importance of innovation and its basis in scientific literature. Among several arguments, he points out that innovation is strongly connected to clusters. For example, companies might be forced to search for new business opportunities or advanced methods of serving clients. This creativity can be necessary in order to survive amidst strong competitors. Another important asset of being located in a cluster is the (often) nearby presence of knowledge institutes. These can be governmental or private bodies specialised in research and development, such as e.g. universities or research centres. An isolated, single firm might have more difficulties in obtaining the benefits of some research programmes.

Porter (2003) states that patenting can be seen as a relatively good proxy for innovation as it is more easily measurable, although it does not capture all industries (e.g. financial services). A strong relationship was found between patenting intensity and average wages, indicating that regions with high levels of productivity (because of more innovation) are also the same places that boost higher wage levels.

New business formation

Porter (2000) indicates that another important attribute of a cluster is the attractiveness for new business formation. The presence of capital providers that are already acquainted with similar firms and local suppliers of inputs and labour close-by are important reasons for new venturing within the same cluster. As local competition keeps firms flexible and competitive, the formation of new business is essential for a prosperous cluster (Porter, 1990). In addition, one will encounter that agglomeration theory is also very relevant in this respect.

Apart from competition, there are other reasons why entrepreneurship is positively related to regional economic growth. For example, entrepreneurship can function as an important carrier for knowledge-spillovers. This argument is made by Audretsch and Keilbach (2008), stating that investments in R&D contribute to economic growth, both direct and indirect (e.g. through new ventures). Therefore, entrepreneurship is a key facilitator in the transfer of otherwise unused knowledge. In another study, Feldman et al. (2005) further researched the effect of entrepreneurs on the formation and rise of a cluster. They find that entrepreneurs can act as catalysers in this respect, next to a number of other conditions such as a high level of education or access to finance. Cluster diversity as a result of new firm entries is another major strength of a successful cluster. Glaeser et al. (1991) found evidence that knowledge spill-overs primarily occur between different industries rather than within. Cluster variety and local competition are therefore essential factors for successful knowledge transfer and thus, a successful cluster.

Many scholars have tried to extrapolate the absolute importance of knowledge apart from other factors that influence cluster performance. Feldman and Francis (2004) indicate that entrepreneurship is an important and key pre-requisite for clusters to develop, in addition to innovation and technological change. They state that entrepreneurship takes a very important place in the first phases of cluster development and that even in the final phases of a cluster a successful entrepreneurial spirit contributes to its success. Finally, Delgado et al. (2010) find evidence that higher levels of new business formation are heavily related with strong clusters. This holds not only for new ventures but also for new branches or subsidiaries of existing MNE's that are elsewhere located in similar clusters.

Survival

The survival rate of firms within a cluster will tell something about whether the business environment is a healthy one, and whether once a firm or start-up has started it continues to exist for a longer period. In addition to the previous part, Delgado et al. (2010) show that being located in a strong cluster significantly improves the changes of start-up survival. They assess the medium-run performance of firms by looking at employment numbers in these new enterprises. However, more research in this field is needed to fully examine the specific

effects of clusters on entrepreneurial spirits and performance. A different study by Wennberg and Lindqvist (2010) measured the effect of clusters on the performance and survival rates of new entrepreneurial firms. Based on an empirical study in Sweden, they find that new start-ups have higher survival rates when located in stronger clusters. These firms also account for a higher economic performance, thus contributing to higher regional economic growth.

The need for more research in this field is supported by contrasting arguments by Folta et al. (2006), who state that one should be careful using survival rates (number of firms that survive a certain start-up period) as a proxy for cluster performance. They state that due to lower switching costs for founders or employees within the cluster, marginal performing ventures might be closed earlier than start-ups located in more remote areas. This is also supported by other scholars, who state that 'dynamism' in the case of competition is positively related to the strength of a cluster (Porter, 1990; De Langen, 2004). Typically, cluster dynamics are promoted by lower switching costs and increased specialization of the different firms. Both differentiation and specialization may add to the performance of the cluster. Therefore, because survival is not one-sided supported by the literature as a key measure for cluster strength, one should be careful using this as a performance indicator.

Acquiring capital

The ease of acquiring capital for a starting firm is another measure of cluster performance. This holds especially for high-tech start-ups, which often need a substantial amount of cash in the early development stages of a product. Therefore, bio-tech or bio-based enterprises generally rely on venture capitalists that have a good knowledge and a vast network within the industry. According to Folta et al. (2006), "the ability and rate at which firms obtain private equity, therefore, represents a signal of good quality and has implications for long-term performance". Mason et al. (2002) argue in a case study that (local) venture capital is very important in developing a well-performing cluster. They base this on the growth that clusters with much local venture capital show compared to clusters with more funding difficulties. An important note that should be made is that 'local' in this respect relates to social distance rather than geographic distance.

A second possibility, in a more mature stage of the firm's growth process, is making an initial public offering (IPO) by launching the firm on a stock exchange in order to attract more capital (Folta et al., 2006). Both ways can be used as indicators for the availability of financial capital and thus cluster strength and performance.

Cluster heterogeneity

In theory, one expects that a diverse cluster with different types of firms outperforms clusters that are more homogenous of nature. However, there has not been much academic evidence found yet in this field and thus there remain some ideas to be confirmed.

For example, Shaver and Flyer (2000) argue that attracting superior firms with very good capabilities are not necessarily beneficial for a cluster as incumbent, smaller firms will run into troubles. They also argue that adverse selection plays a role as “winner” firms in a particular industry will relatively contribute more to a cluster compared to other firms and will thus be less inclined to locate in a cluster.

There is some evidence that a number of diversity drivers are positively related to cluster performance. Brenner (2005) showed that the degree of process innovations and co-operation with supplier and institutions is often higher in industries that are often located in local clusters. It should be noticed that this is not a direct link with cluster performance, although it supports the importance of heterogeneity principle. De Langen (2004) adds as a third driver that a heterogeneous cluster is better resistant against external shocks. For example, if a cluster only relies on the production of one good or service then it becomes very vulnerable to unanticipated changes in a single market.

3. The bio-based cluster in the Flemish-Dutch port Delta

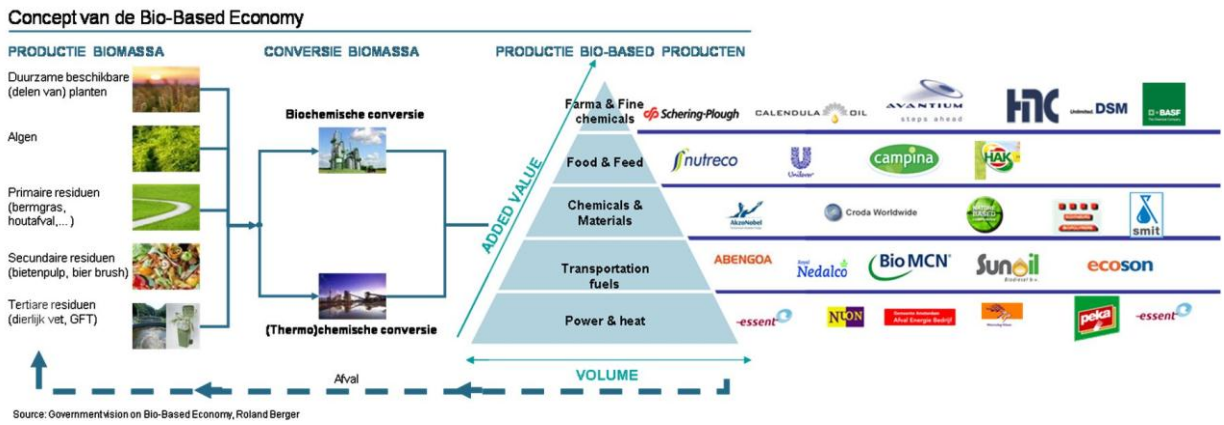
In the previous chapter, a general overview of cluster theory that can be applied to industrial clusters in seaports was provided. In addition, a number of possible performance indicators were identified, some of which will be used later in the empirical part of this paper. After having had a short introduction in part 1, the boundaries of the bio-based cluster in the Flemish-Dutch port Delta will be further defined in this chapter. A distinction has been made between both functional and geographic boundaries, both of which should reasonably limit the scope of this research. Next, an explanation of the chosen variables will be given together with an overview of the operationalization of the study. Finally, some insights about the used data will be discussed.

3.1. Functional boundaries

As has been indicated in section 1.1.1., there are different ways to define the bio-based economy. It should be clear by now that the definition of the bio economy (BE) is too broad and includes e.g. traditional food production. The bio-based economy (BBE) is primarily about the production of non-food products or inputs in a sustainable way.

In addition, one should realize that there is no 'real' sector such as "the bio-based industry" as it entails multiple sectors, including (fine) chemicals, food & agri products, energy and waste recycling. In addition, a distinction can be made between energy production from biomass and the production of bio-based products. In figure 3, an overview of the bio-based economy with its different stages and products is given. Concerning the bio-based economy, one can make a distinction between three different stages of the production process (section 3.1.1.) and two different sectors (section 3.1.2.).

Figure 3: Overview of the bio-based economy



Stage 1	Stage 2	Stage 3	Companies

Source: www.biobasedeconomy.nl

3.1.1. Different stages in the bio-based economy

The first stage is the production of biomass, which consists of primary natural resources such as wood and algae. However, one can also use the rest-products of later stages in the production processes as an input, such as in the case of animal fats or residues. The term "circular economy" is an important notion in the current bio-based trend. According to a growing number of researchers and institutions, it becomes increasingly important to re-use waste and materials in order to shift some pressure away from the earth's natural resources. Therefore, a swing from a linear to a circular economy by using secondary resources might eventually be necessary in order to maintain our current standards of living (ESA, 2013).

In line with the circular economy, one could argue that the production of biomass should not compete with the production of food. Fertile land should primarily be used to feed the population rather than to produce e.g. chemicals or energy products. However, research has shown that there are ways to use less fertile land for e.g. biofuel production without competing with soil that can be used for food (Tilman et al., 2006).

The second stage entails the conversion of biomass, which can be done in various ways depending on the type of input and industry demand. Examples are e.g. fermentation, which is the conversion of bacteria in bio-products and torrefaction, a light form of pyrolysis (improve energy quality).

The final stage is the manufacturing process of different bio-based products. The 'value pyramid' in figure 3 shows the distribution of different products on the basis of value-added. Energy and heat generation are among the lowest in terms of value, whereas biomass conversion into fine chemicals for food and pharmaceuticals is clearly more worthwhile in terms of adding value.

3.1.2. Different sectors

As has been stated earlier, Vandermeulen et al. (2011) distinguish two different sectors in the bio-based economy: bio-based energy and bio-based products. Bio-based energy mainly consists of energy generated by co-firing biomass in traditional fossil fuel (coal) plants, but there are some 100% bio-based energy plants too. It also includes biofuels (bio-ethanol, biodiesel etc.) and bio-based heat.

The term 'bio-based products' is even more complex. One can separate these products into bio-based materials and bio-based chemicals. Material production involves for example the manufacturing of paper and fibres. Bio-based chemicals are the most diverse group, with many different types and purposes for each of them. Traditionally, there has been much less attention for policy in the field of bio-based products compared to bio-based energy

(Vandermeulen et al., 2011). However, as learnt from the previous paragraph, the on-going research in the field of bio-based chemicals is definitely attractive as these are in fact the most valuable products.

3.1.3. Focus

As can be read in Vandermeulen et al. (2011), it will be very important to assess for which type of companies (complete) data will be available. Following step 2 in her research approach ("definition of the optimal level of disaggregation") implies that the bio-based economy can be subdivided in different sectors. In this paper, there will be no specific sectors of the bio-based economy excluded in analysing the size, location and growth of the bio-based cluster in the Flemish-Dutch port Delta. Therefore, the full bio-based economy in the Delta is subject to this research. The recommendations of Vandermeulen et al. (2011) on the selection of the data will also seriously be considered in the operationalizing decisions.

3.2. Geographic boundaries

3.2.1. The Flemish-Dutch port Delta

When we take a first look at the Flemish-Dutch port Delta, one should notice that (part of) this region has been mentioned earlier in the literature, sometimes with a slightly different name (Rhine-Scheldt Delta). In general, the region between the two most important ports in the area, Rotterdam and Antwerp, is in fact the port delta. It is in this area where this research will assess initiatives and companies in the earlier defined stages of the bio-based economy.

In defining the exact boundaries of the delta, this paper follows the definition of the recent co-operation of a number of Dutch and Flemish provinces. These are united in the Flemish-Dutch Delta network, which includes the provinces of Antwerp, North Brabant, East Flanders, West Flanders, Zeeland and South Holland and the most important ports within this region (VN Delta, 2013). Of the seaports located in these provinces, the largest ports are Rotterdam and Antwerp followed by smaller ones such as Zeebrugge and Flushing. Next to a number of bio-based companies that are active in one of these port complexes, many bio-based activities are located in specific clusters in the Delta or have a separate location.

Figure 4: The bio-based cluster in the Flemish-Dutch Delta

Source: Vanelslander et al. (2011)

3.3. Operationalization

3.3.1. Variables to be chosen

Now that the boundaries of this research have been defined, both on the geographical and functional level, a switch can be made back to the literature review. As was stated in part 2, there are different ways to measure the performance of a cluster. In the case of our cluster, the bio-based cluster in the Flemish-Dutch port Delta, only some indicators are relevant and appropriate. Therefore it is necessary to make a selection of the right performance indicators. Several important aspects were considered in this decision, which will be explained below.

The vast majority of the indicators found in the literature have similar problems, mainly caused by a lack of measurement, quantification or availability. The latter will be the biggest challenge as 100% coverage by a performance indicator will be difficult to obtain. Another important consideration in the decision process is the fact that we deal with a special type of cluster. The bio-based industry is a relatively new type of industry (or a new combination of existing industries), which means variables that measure innovation or other forms of early

progress might be insightful. However, because this cluster will not be compared to other bio-based clusters, these indicators are not particularly necessary to use in this research.

In order to answer the main research question, a distinction must be made in the analysis of growth, location and size of the bio-based cluster respectively. The indicator decision is relatively straightforward for the localization question (mapping all companies). For size and growth however, a well-chosen set of indicators is needed for a thorough analysis of the cluster's characteristics. In table 3, a short overview is given of the decisions that were taken in selecting the right variables. For more details, one should refer back to the earlier discussed literature on performance indicators and the overview in table 2.

3.3.2. Location

First, it is necessary to assess the location of the different bio-based companies in the Delta. No explicit performance indicators are analysed here as the obvious indicator for this is the address of each firm. These locations can be mapped in order to view any specific cluster characteristics within our earlier defined geographic region. For example, do bio-based firms mostly locate close to each other? And could it be that due to the circular character of the bio-based economy, firms in different stages benefit from being located closely to each other?

3.3.3. Cluster size

As one of the main goals of this research, it is relevant to assess the current size of the cluster. Cluster size can be measured in different ways, with often overlap among the possible indicators that are suitable. Based on our analysis earlier, the *number of employees and firms* located in the cluster will provide good estimates of the current size of the cluster. For the number of employees, the year 2011 is chosen. For this year, most companies have data on these variables. In addition, *Foreign Direct Investment* will be added as a third variable, including mutual relationships between firms in the cluster.

3.3.4. Cluster growth

Regarding the growth of the bio-based cluster, one can use the same performance measures as for size, as long as these are measured over time. Therefore, the *number of employees and firms* will also be used here. The practical approach will mainly differ in the fact that growth can be measured at specific points in time. In this way, the development of the cluster should become visible. As a starting point, the years 2007 and 2011 will figure as two points in time.

Table 3: Operationalization of performance indicators

Performance indicator	Description	Research objective	Operationalization
Foreign Direct Investment (FDI)	Inward FDI is positively related to cluster performance, (international) linkages are important	Cluster size	The number of foreign subsidiaries can be measured. In addition, ownership links between firms are explored.
Labour: wages and employment	Wage levels will not be included because of the small regional scale. Therefore only employment	Cluster size, cluster growth	Employment trend over the years. Current number of employees in the cluster
New business formation	New business formation is an important attribute of a successful cluster	Cluster growth	Measuring the growth of the cluster at fixed points in time

3.4. Data

3.4.1. Databases

In order to quantify the chosen variables, several sources have been used to construct a database that is as much complete as possible (appendix 1). Because the bio-based industry consists of parts of other industries, comprising not only agriculture but also chemicals and energy, there are no separate SIC- or industry codes for the sector. This means that there is not one database available with only bio-based companies included. An alternative can be found by using other sources of data that have been introduced by several different promoters of and institutions related to the bio-based economy. An overview of the indicators and the main data sources is provided in table 4.

The main sources for retrieving the different companies that are active in the bio-based economy are the websites www.biobasedeconomy.nl, www.biobaseddelta.nl, www.biobasedinnovations.nl and www.cinbios.be. Biobasedeconomy.nl is an initiative of Agentschap NL, the Dutch agency for innovation and sustainability of the ministry of Economic Affairs, Agriculture and Innovation. Biobased Delta is a joint coalition of businesses, local government and knowledge institutions in the south-west of the Netherlands (North Brabant and Zeeland). BioBased Innovations exists of a programme developed by several organisations in the south-west region of the Netherlands, stimulating innovative ideas in the bio-based sectors. For the Belgian provinces, the Cinbios membership list provided the data of a number of bio-based companies active in Flanders. Cinbios is an initiative of FlandersBio, Ghent Bio-Economy Valley and essenscia, a Flemish organization for the life sciences and chemical industry. It should be noted that Cinbios is the

Flemish database for so-called ‘industrial biotechnology’ or ‘white biotech’ companies. There exist no differences between these terms and the notion of bio-based companies.

In addition, there are a number of specific clusters within the Flemish-Dutch Delta that consist of several companies active in the bio-based industry (table 6). Their websites also contain overviews of the cluster members and provide insight in the nature of these firms. The data sources altogether form a list, most likely including the majority of companies active the bio-based economy in the Delta. A number of firms might not have been included because they were not listed in one of the used sources. In addition, it should be noted that the term ‘bio-based’ is primarily a term that a company can give itself. By subscribing to one of the earlier mentioned websites or institutions, it becomes public that a particular company is active in the bio-based economy.

Table 4: Data availability of performance indicators

Research objective	Performance indicator	Year(s) of measurement	Number of observations	Main sources
Size	Employment	2011	73	Orbis/BvD, Eurostat
	Firms	2013	91	BioBased Economy, Biobased Delta, BioBased Innovations, Cinbios
	FDI	2013	18	Orbis/BvD
	Mutual relationships	2013	11	Orbis/BvD
Growth	Employment	2007, 2011	48	Orbis/BvD, Eurostat
	Firms	<1990 - 2013	87	Orbis/BvD

Once the firms are identified, specific firm data about these selected companies can be found in firm databases. Here, the Orbis/Bureau van Dijk and Company.info databases were used in order to gather the right figures on each company’s historic and current characteristics. Eurostat has been used to obtain figures about the regional economies in order to compare the bio-based economy in assessing its relative size and growth. Port websites and several statistical documents have been used to extract specific port figures on employment.

3.4.2. Data availability and limitations

In order to thoroughly analyse the bio-based cluster in the Flemish-Dutch port Delta, one would have to start with full data coverage. However, as the bio-based economy is a very recent cross-sectoral industry, there is no extensive information available on the number of firms and their business activities. This is underlined by the fact that there are no specific SIC- or NAICS-codes available for the bio-based industry, which makes it impossible to use existing firm databases appropriately. For the future, this could be one of the first (and most important) steps in improving the research quality of a similar type of study.

The lack of available data has played an important role in the process of choosing the right performance indicators. For example, employment is chosen as an indicator as it is widely reported by the firms in the database. Other firm data will most of the time not be available, which holds especially for the so-called 'ZZP' firms that only employ the owner. These firms often lack consistency in their yearly and publicly available (financial) results. This is another major point of improvement, but it is not expected that this will be changed in the near future due to the fact that there is no legal obligation for these firms to disclose their yearly results.

On the other hand, the medium- and large size firms require other considerations, mainly caused by the often diverse array of business activities. Therefore, it can be difficult to separate e.g. the bio-based chemicals from the traditional chemicals line. This has as a result that the effects and sizes of the effects can become blurred, something that is almost inevitable in this particular study in this early phase of the bio-based economy. The situation can only be improved when these firms will separately report their bio-based activities either in their annual statements or start a new subsidiary. As a last note, much of the problems concerning the limited availability of data should be contributed to the current (early) phase of the bio-based economy. When the sector will firmly establish itself in the future, some of the data problems might be mitigated.

4. Performance analysis of the bio-based cluster in the Delta

In this chapter, an overview of the results on the different performance indicators will be presented. Three questions need to be answered: Where is the bio-based cluster located in the Delta? What is its current size? What is the growth of the cluster?

First, the location will be analysed by means of mapping the companies. After this important step, it will be possible to infer some direct results based on the companies' locations. Second, an analysis of the indicators for cluster size will be given. The indicators comprise the number of firms, employment figures, FDI and mutual relationships. The growth of the cluster will be analysed by means of analysing both the number of firms and employees over the past years. Growth in employees has been studied for the years 2007 and 2011, whereas the number of firms has been analysed on the basis of their origination date.

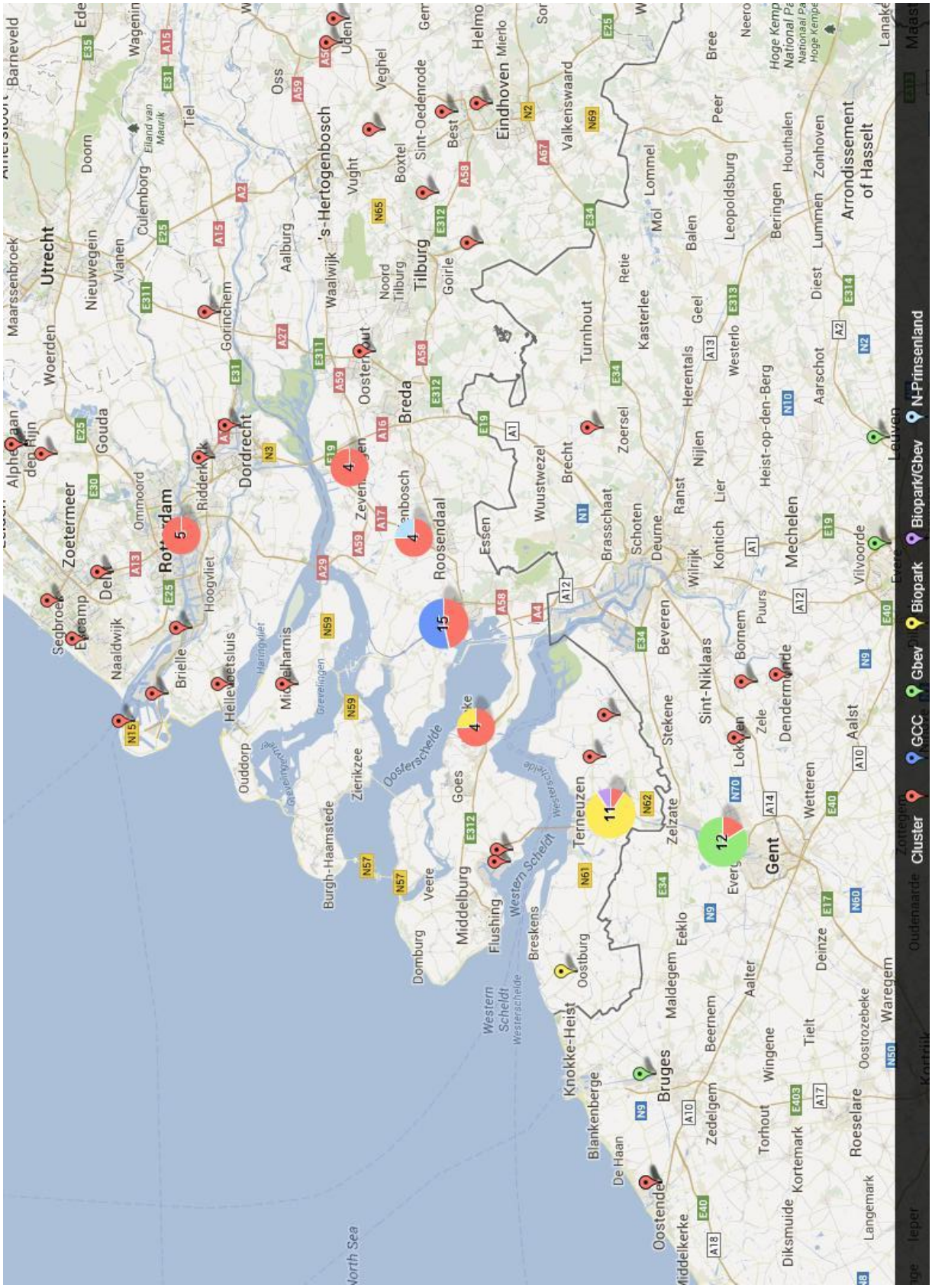
It is necessary to compare the size and growth of the cluster in order to assess its (relative) importance. However, as the bio-based economy clearly is a new phenomenon, it is difficult to find comparable peers elsewhere. Hence, the decision has been made to compare the results against regional figures.

4.1. Location

The first part of the research question to be answered is the 'location' of the bio-based cluster in the Flemish-Dutch port Delta. In order to do this, a graphical representation of the database of bio-based companies is used. This map was generated by the website www.batchgeo.com, an online map maker. As has been referred to earlier, Appendix 1 includes the list of firms active in the bio-based economy. Figure 5 provides the visual representation of this list of firms.

One can view from the map that many of the firms are concentrated in specific areas. In the bio-based economy, these concentrations or clusters sometimes exist of a number of firms that are linked by resource- or wastestreams (Biopark Terneuzen). It can also be the case that there is one incubator that provides acces to its resources to other firms and start-up companies (Green Chemistry Campus). More emphasis will be placed on these smaller clusters in section 4.1.1 and 4.1.3.

Figure 5: Map of firms in the bio-based cluster in the Flemish-Dutch port Delta



Source: www.batchgeo.com

Figure 6: Map of ‘small’ bio-based clusters in the Flemish-Dutch port Delta

Source: www.batchgeo.com

A next important finding is the specific location of bio-based activities in the Flemish-Dutch Delta. It can be noticed that especially the western part of North-Brabant, Zeeland and Eastern Flanders boast the most firms and clusters (figure 5 and 6). It is arbitrary to arrive at a definitive number of firms because of the non-existence of specific geographic boundaries, but the map gives a good indication of the bio-based ‘gravity points’ in the region.

The Flemish-Dutch Delta is a transnational region, as it includes both provinces of the Netherlands and Belgium. Of the total 91 bio-based firms in the database, more than 75% is located in the Netherlands (table 5). In the remainder of the analysis, there will not be much

focus on each country in particular as the Flemish-Dutch Delta as a whole remains the geographic playing field. There are good examples where both Dutch and Flemish parties co-operate in the field of bio-based activities. One of the examples of co-operation between the two countries can be found at the Biopark Terneuzen and Ghent Bio-Energy Valley clusters, which are both located along the Ghent-Terneuzen canal. Their joint efforts in the development of Bio Base Europe, an innovation and training accelerator, are exemplary for the Dutch-Belgian commitment in further developing the bio-based economy.

Table 5: Firms located in each country

Country	Number of firms	%
Netherlands	70	77%
Belgium	21	23%
Total	91	100%

Table 6: Smaller bio-based clusters within the Flemish-Dutch port Delta

Map	Cluster	Location	Important stakeholders
C	Biopark Terneuzen	Terneuzen, The Netherlands	Zeeland Seaports, Provincie Zeeland, Hogeschool Zeeland, Wageningen UR
A	Ghent Bio-Energy Valley	Ghent, Belgium	Ghent University, Port of Ghent, City of Ghent, Development Agency East-Flanders
B	Green Chemistry Campus	Bergen op Zoom, The Netherlands	SABIC, Provincie Noord-Brabant, gemeente Bergen op Zoom, REWIN West-Brabant
D	Nieuw-Prinsenland	Steenbergen, The Netherlands	Suiker Unie, de Tuinbouwontwikkelingsmaatschappij
E	Rotterdam Bio Port	Port of Rotterdam, The Netherlands	Port of Rotterdam, Rotterdam Climate Initiative

4.1.1. Smaller clusters within the cluster

At first, it is clearly noticeable that there are a number of smaller clusters within the larger Rhine-Scheldt Delta (table 6). These small clusters include approximately one-third of the total number of firms in the Delta region. This has also been mentioned by the SER (Sociaal Economische Raad), who find that (Dutch) developments in the bio-based economy typically occur on a regional scale (SER, 2010). In their report on chances for the bio-based economy, they see this as a “bottom-up” phenomenom that should primarily be controlled by local government bodies. This is in line with current national policies on handing out more responsibilities to local and regional governments.

Table 7: Smaller bio-based clusters and their firms

Cluster	Company, Institution	Product	Stage
Biopark Terneuzen	BIO BASE EUROPE	*Center for bio-based innovations*	Other
	Cargill (NL)	*Alcohol (3) - Water, starch, steam and heat (circular)*	3, Circular
	Dow Benelux	*(Biobased) chemicals*	3
	DSD Betaprocess	*Hydrolyse technology*	2
	Ecoservice-Europe	*Biomass transport + supply*	1
	Heros Sluiskil	*Waste recycling / biogas, biodiesel*	3, Circular
	ICL-IP Terneuzen	*Bromine and recycling*	Circular
	Lijnco Green Energy	*Biobased gas+electricity*	3
	Sagro	*Waste recycling*	Circular
	WarmCO2	*Heat and CO2 for agriculture*	Circular
	Yara	*Fertilizers*	Circular
	Electrawinds ReFuel / Greenfuel	*Energy/ Biodiesel*	3
Green Chemistry Campus	Aiforo	*Conversion (new) wet biomass conversion technqiue + advice*	2
	Alpha Enzymes	*Biobased chemicals*	2,3
	Bioclear	*Consultancy and research*	Other
	BioTorTech	*Biomass conversion technique / Torrefaction technology*	2
	Millvision	*Consultancy and research on bio-based activities/innovations*	Other
	Progression Industry	*Biodiesel*	3
	Retoplast	*Biobased plastics*	3, Circular
	SABIC Innovative Plastics	*Chemical products*	3
Ghent Bio Energy Valley	Alco Biofuel	*Bio-ethanol*	3
	BIO BASE EUROPE PILOT PLANT	*Center for bio-based innovations*	Other
	Bioro	*Biodiesel*	3
	Capricorn	*Venture capital fund*	Other
	Desmet Ballestra	*Production of plants and production processes*	2,3
	EDF Luminus	*Heat*	3
	Electrabel	*Bio-electricity*	3
	Genencor	*Biomass conversion*	2
	Oiltanking	*Storage of biofuel*	3
	Oleon	*Biochemicals*	3
	OWS	*Building bioplant, R&D, waste management*	2
	Sea-Invest	*Storage of raw materials*	1
	Storaenso	*Biomass producer*	1

Nieuw-Prinsenland	Suiker Unie	*Biogas*	Circular

In tables 6 and 7, an analysis has been made of the different, smaller clusters with the firms that are part of them. The firms in the Rotterdam Bio Port cluster are excluded in the analysis, which will be further explained in the following section 4.1.2. For reasons of comparison, the few firms that are included in our research that are part of that cluster are not analyzed as a cluster as such. The results would be skewed as this cluster is in reality larger than could be expected from the used datasources. In addition, related to the cluster definition, it can also be argued that there are only minor relationships between the firms in terms of bio-based activities. This means that in contrast to e.g. the Biopark Terneuzen cluster, there appear to be relatively few (circular) links between the different companies located in the Rotterdam Bio Port. This could be due to the fact that the companies located in the Bio Port are relatively large and do not rely on an incubator nor on co-operations with other companies. However, this is often the case in the other smaller clusters.

A special remark should be made for the Nieuw-Prinsenland cluster, which thus far only includes one firm (Suiker Unie). The development of this agro-cluster has only been very recent and the acquisition for new cluster members is currently still being done.

4.1.2. The ports of Rotterdam and Antwerp

The Flemish-Dutch port Delta is known for its location between two major European seaports, Antwerp and Rotterdam. This geographic region generates multiple opportunities for companies to benefit from immediate access to each of the two ports. Good examples are the large amount of transport and logistics companies or chemical plants located in or near the seaports. One would expect that these port complexes also provide a fertile place for the bio-based industry, especially regarding bio-based chemicals or energy. However, it appears that both seaports do not play their expected roles in hosting (important) bio-based companies.

Port of Rotterdam

As mentioned in section 4.1.1., there is a bio-based cluster in the Rotterdam port, called Rotterdam Bio Port. The reason why this cluster as such is not included in this research is related to the type of companies it incorporates. The majority of companies that are active in the Rotterdam Bio Port area are large storage, chemical or energy companies for which their bio-based business is just a small fraction of their total activities. As one can see in PoR (2013), a presentation on the current stance of the Rotterdam (petro-)chemical and bio-based cluster, the port of Rotterdam is already a large player in feedstock (storage) and biofuel/bio-energy production. On the other hand, it remains a smaller actor in the field of

bio-based chemicals. In order to let the bio-based cluster grow, a new area (200 acres) at Maasvlakte 2 is destined for new businesses. Recently, the port authority has lauched a 'plug and play' concept which will enable these new businesses to start-up quickly (PoR, 2013). Services in terms of power, waste collection, water and storage will be readily available. This new initiative follows the strategy of the port authority to become a world-class 'bioport'.

Port of Antwerp

Another major port in the region, the port of Antwerp, also appears to play a minor role in current developments in the bio-based economy in the Delta. Following the list of companies in the database and their location, there are no bio-based companies located in the port of Antwerp area. Similar to developments in the port of Rotterdam, several institutions are setting out to (re-)generate old port areas into innovative places for new 'green' businesses and research facilities (Blue Gate Antwerp, 2013). In addition, there are large energy and chemical plants that use 'green' feedstock either in co-firing or in their production processes. However, there are no real signs of an active bio-based cluster and the port therefore does not play a premier role in this respect, contrary to what one might expect.

4.1.3. The circular characteristic of a bio-based cluster

One of the key features that characterizes the functioning of the bio-based economy is the fact that it represents a circular economy. In other words, many of the rest-products and much of the waste that is generated during production or consumption processes are recycled and re-used as new inputs for the economy. In this way the linear economy is replaced by a circular one, thus creating a loop.

In order to reach this new state of the economy, the links between companies in different stages of the production process are very important. As one company might only be active in the third phase (products), it will not have a purpose for its generated waste. This waste however can be re-used as an input by another company upstream. In the several clusters within the Delta, one can encounter many examples of firms sharing their resources or waste in order to create circularity.

Biopark Terneuzen is a good example of a cluster that stimulates this circularity among its members. Some of the mentioned benefits for the incumbent firms are lower storage and disposal costs and tax savings (Biopark Terneuzen, 2013). In table 8, one can find the existing links and waste streams within this cluster.

Table 8: Circular character within the Biopark Terneuzen

Stream/link	Companies involved
Biomass	Greenhouse complex → Biomass plant (Electrawinds ReFuel / Greenfuel)
Electricity	Biomass plant → Other companies
Water	Biomass plant → Recyling company (Heros)
Heat (from other companies)	WarmCO2 → Greenhouse complex
CO2	Producer of fertilizers (Yara) → WarmCO2
Starch, water, energy and steam	Agricultural producer (Cargill) → Alcohol plant (Cargill)

Source: www.bioparkterneuzen.com

4.2. Cluster size

The second part of the main research question is about the aggregate size of the bio-based cluster in the Delta. This can be measured in various ways, but in this research only the earlier chosen variables in chapter 3 will be used. This includes the number of firms, employment, FDI and mutual relationships respectively. For employment and the number of firms, an analysis will also be made for the firms located in the smaller clusters within the Delta.

4.2.1. Number of firms

The first obvious indicator is to identify the number of firms that belong to the bio-based cluster in the Delta. Based on the earlier mentioned websites and data sources, a total of 91 firms have been selected that fulfil the criteria of the bio-based definition (table 9). Of these 91 firms, a slight majority of firms are so-called 100% bio-based firms. These firms only produce products or services with a bio-based character. The other half of the sample contains firms that are active in the bio-based industry, but also have more traditional business activities.

Table 9: Type of bio-based firms

Type of firms	Number of firms	Percentage
100% bio-based firms	47	52%
<100% bio-based firms	44	48%
Total of bio-based firms	91	100%

34 firms out of 91 are located within one of the smaller clusters. This means that approximately one-third of firms are part of a larger, mutually related group of businesses in the same industry (table 10).

Table 10: Firms active in smaller clusters within the Delta

Total number of firms	Firms located in smaller clusters	% located in smaller clusters
91	34	37%

Based on the defined phases of the bio-based economy, the firms can also be grouped according to their main bio-based occupation. In table 11, firms that are active in multiple stages of the bio-based economy are included in each of these. Therefore, the total count of firm's activities is 107 instead of 91. The percentages are measured on the basis of the total number of firms (91).

Table 11: Firms active in the bio-based economy

Stage	Typical activities	Number of firms	Percentage	Examples
1	Production and storage of biomass	16	18%	NNRGY, Storaenso, Sea-Invest
2	Conversion technology	15	16%	Clea Technologies, BioTorTech, C2Circle
3	Bio-based products and bio-based energy	49	54%	Alco Biofuel, Cosun Biobased Products, Purac Biochem
Circular	Recycling, re-using materials	18	20%	Suiker Unie, Yara, LambWeston
Other	Consultancy, finance, institutions	9	10%	Bio Base Europe, Capricorn, Millvision

One has now seen an overview of the different types of firms and their place in the bio-based economy. It is clear that most stages comprise roughly the same amount of

companies, apart from some specialized institutions or capital funds. The third phase, however, is clearly the best represented with 54% of the total number of firms in the dataset. There are several possible explanations for this. First, it could be suggested that with only a few different types of biomass (e.g. algae, wood pellets and waste) a multitude of different bio-based products can be made (figure 3).

A second reason could be that most value is created in the latter part of the bio-based chain. With fine chemicals and pharmaceuticals topping the list (figure 3), most added value probably lies in the production of bio-based products rather than biomass itself. Another important aspect is that in the case of biomass, large volumes might be necessary to generate high returns, which could be difficult for a start-up company. This can be due to the fact that first generation feedstock (crops) is increasingly costly to grow e.g. because of the vast amount of land needed, expensive processing machinery or opportunity costs. For example, large-scale production of algae as a source for biofuel has only recently started on a commercially viable basis (Design News, 2013).

There is still much research and development being done to extend the range of possible products. This will probably lead to an even larger difference between the number of firms active in the first and third phase of the bio-based economy. The results presented here (table 11) are more or less in line with what could be expected from the used definition of the bio-based economy. The focus lies mainly on the conversion of different types of feedstock into products or fuels. There is also evidence for the circularity aspect, as there are a reasonable amount of firms active in this part of the production chain. It will be interesting to see how the circular character of the bio-based economy will develop or keep up with the expected growth in bio-based products.

The fact that the bio-based economy as a whole is still under development can be seen from the total sample size of 91 firms that was used here. The significance of its current contribution to the total economy can therefore be doubted, however as one can read in section 4.3., the industry is still gradually growing. Both issues have also been addressed by the Working Group Businessplan BBE 2.0, who found that the ‘young’ bio-based economy “has reached a take-off phase” (WG BBE 2.0, 2011). According to the working group, the current amount of investment and the strong ambitions of both public and private parties prove that the bio-based economy can become an important part of the Dutch economy in the future. They find, however, that large investments will remain necessary in the upcoming years to ensure that the full potential of the bio-based economy can be achieved.

4.2.2. Employment figures

Starting with the analysis of employment data of the constructed bio-based firm's database, it is necessary to determine which year is best for this analysis. The year 2011 is used as for most firms this is the most recent point in time for which data is available. Another remark has to be made about the sample of firms, which is split in 2 different results in table 12 (N=73). The first row indicates the number of people working at 100% bio-based firms, meaning that these companies and their workers are fully committed to bio-based activities. The row below also includes those companies that exploit bio-based activities only as a part of their business activities.

A number of assumptions have been made in order to construct this table. ZZP firms are regarded as having one employee. In addition, the 13 'ZZP' firms for which data was available before and after 2011 showing that the company was a ZZP firm were also recognized as a ZZP firm in 2011. Other (larger) companies that did not publish their 2011 figures are not included this overview. For matters of consistency, we also left the large electricity companies out of our overview (EPZ, Electrabel and EDF Luminus) as for none of these very large companies a specific overview of bio-based activities can be extracted. It can be expected that the relative significance of their bio-based activities compared to other business activities is low. Other large corporations such as the chemical companies SABIC (the incubator of the Green Energy Campus), Dow and DuPont can also influence the current figures. These firms each employ generally between 500 and 1500 employees and it is not clear how many of these workers are involved in bio-based activities. Within the scope and reach of this research, there is no possibility to solve this issue.

Table 12: No. of employee's bio-based industry 2011

Type of employment	2011	%
100% bio-based employment	570	8%
Partly bio-based employment	6527	92%
Total bio-based employment	7097	100%

As stated earlier, a number of smaller clusters within the Flemish-Dutch port Delta can be identified, each consisting of a number of interrelated firms active in the bio-based economy. These clusters employ a large number of people, of which the details can be found in table 13. The data in this overview give a slightly skewed view on the real numbers as large employers such as EDF Luminus or SABIC are not included in the results. However, even

without these companies, it is clear that the majority of people (62%) that are active in the bio-based industry are active in one of the firms located in a bio-based cluster.

Table 13: Employees active in the smaller bio-based clusters in the Delta

Cluster	Employees	Sample size	Missing
Biopark	2886	11 out of 12 firms	Bio Base Europe
Gbev	1463	11 out of 14 firms	Bioro, EDF Luminus, Electrabel
GCC	43	6 out of 8 firms	SABIC Innovative Plastics, Retoplast
Nieuw-Prinsenland	3	1 out of 1 firm	n/a
Total	4395	29 out of 35 firms	

One can also compare the number of employees against regional employment. This is done in table 14, where the labour force (total number of workers aged 15-64) in the six provinces is aggregated and compared with the number of employees at bio-based firms. Three regional statistics have been used: total employment, port employment (both transport and industrial employment in the ports of Zeebrugge, Ghent, Ostend, Antwerp, Rotterdam and Zeeland Seaports) and employment selected by economic activity (NACE-code). These employment figures have been generated using the Eurostat databases, the Belgian National Bank and the individual port websites.

From the results in table 14, one should immediately notice the relatively low share of 100% bio-based firms. This conclusion might follow as a result of the cross-sectoral character of the bio-based economy, ranging from agro-production to the manufacturing of fine chemicals and recycling. It is a very broad industry, which means that many existing companies have recently been experimenting with new bio-based techniques. For example, companies such as Franken Inox, Synbra/Biofoam and Purac have developed additional business activities in the bio-based sector next to their traditional operations. Another reason is that the notion of ‘bio-based economy’ and its implications have only been broadly recognised since a few years. This has also led to a lower number of counts in 2011 (being 73 compared to a total of 91 firms). Among the excluded firms, 6 (100% bio-based) start-ups can be identified that have been launched after 2011. For the other missing firms or institutions, there was no data available for the year 2011.

Table 14: Employment in the Flemish-Dutch Delta in 2011

Type of employment	No. of employees	% of port employment	% of agro/ind. employment	% of total employment
100% bio-based employment	570	0.28%	0.07%	0.01%
Partly bio-based employment	6527	3%	0.82%	0.13%
Total bio-based employment	7097	3%	0.89%	0.14%
Port employment	204302		26 %	4%
Agro, industrial employment (NACE-R1 & R2)	794100			16%
Total employment	5023400			

Source: Eurostat, NBB, PoR, Zeeland Seaports

When combining these employment results with the analysis of the number of firms active in the bio-based economy, one can draw some immediate conclusions. As the majority of firms is 100% bio-based but they only employ 8% of the total number of employees, this implies that 100% bio-based firms are generally small companies. This is not surprising when examining the list of firms, which includes many large traditional chemical corporates that often employ more than 500 workers each.

From table 14, it becomes once more evident that the bio-based economy as a whole is still a relatively small sector in terms of employment. Compared to total employment in ports in the Delta, bio-based activities account for roughly 3%. However, these activities account for less than 1% of related industrial activities and only 0.14% of total employment.

In figure 1 on the size of the Flanders bio-based economy by Vanelslander et al. (2011), it stated that 0.4% of the labour force in Flanders is active in the bio-based industry. Similar research on the provincial level by Bakker et al. (2012) indicates that roughly 0.2% of the working population in South-Holland works at a bio-based firm. It would seem that the Dutch part of the Delta is somewhat lagging in this respect as both Bakker et al. and this study arrive at a lower share. However, one should be careful with such interpretations and comparisons as the selection of companies is most likely based on different assumptions. In the growth section, a closer look will be given at the 2011 figures in a comparison with the year 2007.

4.2.3. Foreign Direct Investment

Within the bio-based cluster in the Flemish-Dutch port Delta, a number of multinationals are active, primarily by having started a subsidiary here. In figure 7, one can observe the countries of origin for each of the foreign-owned bio-based firms in the Delta. For the number of firms, this sums to a total of 18 branches/subsidiaries. When only considering 100% bio-based firms, this number is much smaller (only 4).

Figure 7: FDI (number of firms) in the bio-based economy

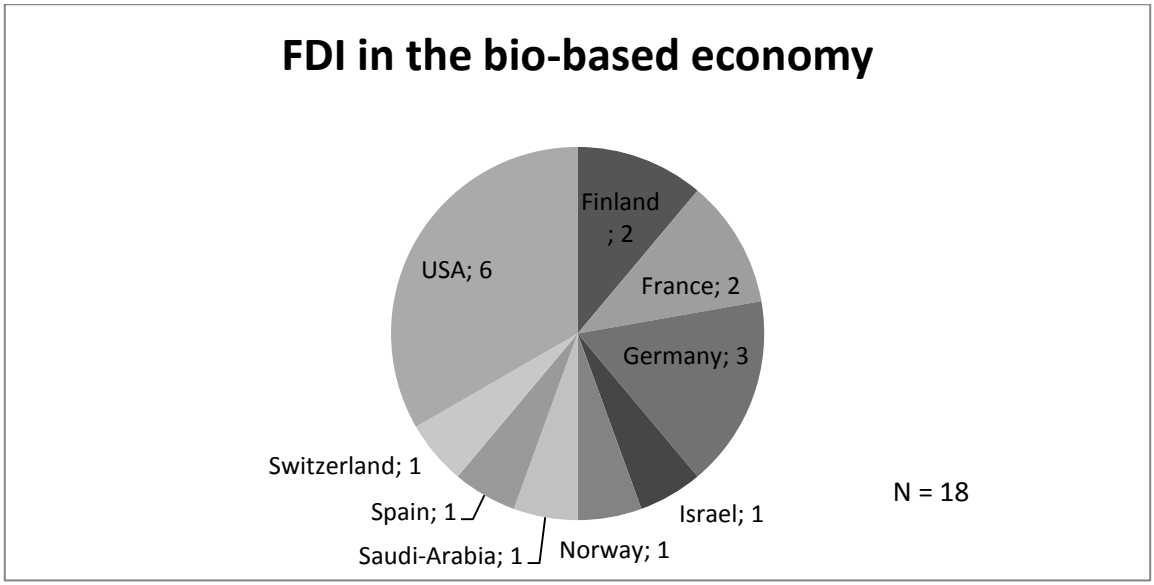


Table 15: FDI (employees) in the bio-based economy

Type of firms	Employees (2011)	% of bio-based employment	Sample size
Firms with FDI	5087	72%	13 out of 18

From figure 7 it is clear that the United States and Germany host most of the parent companies (together 50%) that are active in the Delta. The firms are mostly active in the third phase of the bio-based chain (manufacturing products such as chemicals or supplying electricity). Another important category includes large firms that have started a circular process for their waste. This waste is then often re-used as biomass for heat or energy. As these circular processes require significant investments in technology, it becomes evident that mainly the larger corporations can invest in these developments.

In terms of employment, one can observe that the firms involved in FDI employ the majority of employees in the Delta's bio-based economy. For 13 of these firms, 2011 employee figures were available and totalled 5087 workers (table 15). This is about 72% of total employment in the same year in the bio-based industry in the Flemish-Dutch Delta. The fact

that so many employees are employed by foreign firms or their subsidiaries can be well explained. These firms are often large multinational (chemical) corporations that operate on a world-wide scale and have large production facilities.

4.2.4. Mutual relationships between firms

As stated, FDI is the link between a foreign parent company and its local subsidiary but one can also have links between different companies in the cluster. These links can be informal, through knowledge 'pipelines', or formalized in a particular ownership structure such as a joint venture. In the Delta, apart from FDI one can observe 11 of these ownership vehicles and other formal relationships (table 16).

Table 16: Mutual (formal) relationships in the bio-based economy

Firm	Product	Stage	Type	Ownership
AF&F	Manufactures bioreactors for algae	1	Joint venture	BioSoil, Tendris
Avecom	Waste water treatment	Circular	Subsidiary	Proviron
Biomoer	Biogas + heat/energy	3	Joint venture	Melkveebedrijf Hulsen Kwappenberg, Kwekerij Loos, Melkveebedrijf Maas, Akkerbouwbedrijf van Tiggelen
Bioro	Biodiesel	3	Joint venture	Cargill, Biodiesel Holding, Vanden Avenne Izegem
Bird Engineering	R&D for new conversion techniques	2	Subsidiary	Corbion Purac
Crustell	Biobased products on basis of agricultural waste	3	Subsidiary	Cosun
Ecoson	Energy products from byproducts	3, Circular	Subsidiary	VION
EcoSynth	Chemical R&D (sustainable)	2	Joint venture	Jes projects, Proviron
S.E.S. International	Biodiesel	3	Joint venture	Marine Olie Holland, Bewa Groep
Soltens	Reprocessing of byproducts	3, Circular	Subsidiary	Cosun
WarmCO2	Heat and CO2 for agriculture	Circular	Joint project	Zeeland Seaports, Yara

A reason why firms might want to participate in a joint venture in the bio-based economy has much to do with scale effects. For example, in the case of Biomoer (a biogas producer), one farmer did probably not produce enough biomass but four companies altogether managed to start this project. In other cases, firms are searching for expertise in other companies e.g. S.E.S. International. Searching for these new links is a typical characteristic of the bio-based economy and its circular and cross-industrial character.

4.3. Cluster growth

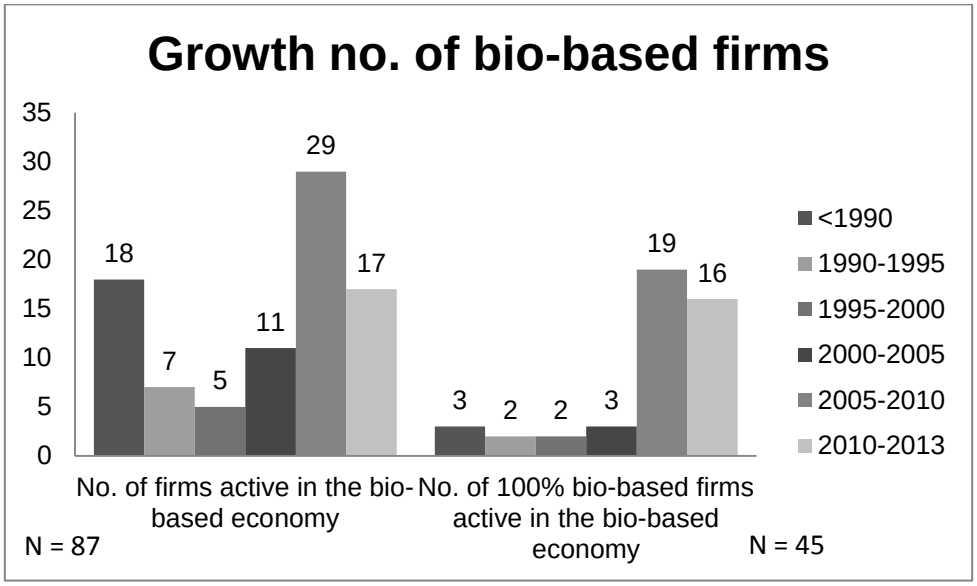
The third part of the research question includes the analysis of the growth of the bio-based cluster in the Flemish-Dutch port Delta. For this, similar indicators are used as in the previous part on cluster size, but due to limited data availability fewer results can be obtained. First, changes in the number of firms active in the bio-based economy will be analysed. Thereafter, the growth in employment at 100% bio-based firms will be shown. There will be no analysis of growth patterns on the smaller cluster level because of the difficulties associated with cluster dynamism, which makes it often unclear how a cluster developed or which companies contributed and in what way.

4.3.1. Growth in the number of firms

The number of firms in the bio-based economy is expected to have grown over the years. As earlier explained, the phenomenon ‘bio-based’ is still relatively young and many start-ups and larger corporations are increasingly researching and developing new products and techniques. In figure 8, one can clearly identify the growing trend in this sector as more than half of the firms (65%) or their local subsidiaries have been established after the year 2000. In the same figure, the growth of 100% bio-based firms can also be examined. Although the sample is about half of the total company dataset, it shows the reader some clear results. Most importantly, the majority of the firms that are 100% bio-based has been established from 2005 onwards.

In order to construct this overview, the data have been edited in order to fit most appropriately. For example, the denoted years in the figure reflect the year of foundation. In addition, large (multinational) corporations that have taken over Dutch chemical sites are denoted in the year of the takeover. The reason for this is that with the takeover often changes in corporate policy are made.

Figure 8: Growth of the number of bio-based firms



On a smaller regional scale, it is difficult to detect the growth of the various clusters within the Delta. Although it is known in which year each company was founded, it is not always clear when a company started to actively contribute to the cluster. Therefore, an overview has been made to show when a cluster was first founded, which can be seen in table 17.

Table 17: Year of foundation of smaller bio-based clusters

Cluster	Year
Biopark	2003
Gbev	2005
Nieuw-Prinsenland	2010
GCC	2011

One can see some obvious differences in figure 8. The main difference lies in the number of firms that were started in the years from 2005 onwards. Here it is visible that in the sample for 100% bio-based firms the growth trend is much steeper than for bio-based firms in general. It can be concluded that bio-based activities for all companies are becoming more interesting. However, it appears that only since a few years it is worthwhile to solely focus on this type of business without any other supporting activities. This can be explained by the fact that the notion and existence of the bio-based economy are relatively young. In 2005, it was the ministry of Agriculture, Nature and Food Diversity that started working on the bio-based economy in the Energy Transition scheme (Ministerie van Landbouw, Natuur en

Voedselkwaliteit, 2008). Since then, more initiatives related to the bio-based economy have been taken, with and without support of the European Commission.

The current growth trend in the bio-based economy and the number of firms is likely to continue. Vandermeulen et al. (2010) expect the significance of the bio-based economy in Flanders to quadruple by 2030. They see biofuels as one of the products with most growth potential. In addition, it should be noted that much attention is still needed for bio-based products. It appears that bio-energy is still subject to much policy but that e.g. chemicals based on 'green' inputs are still less promoted.

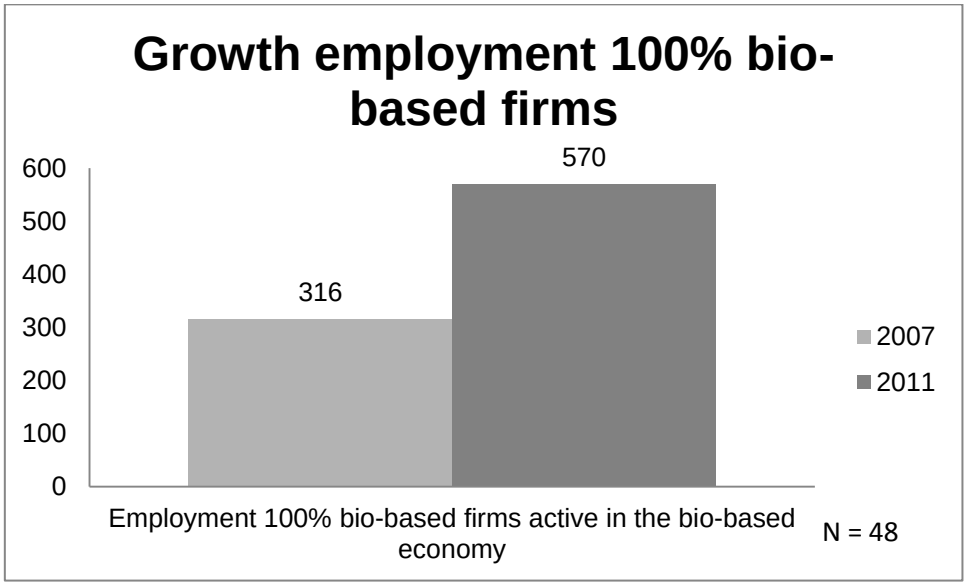
This need for policy has also been noticed in a broader aspect by HCSS and TNO in an assessment of the bio-based economy in general. They argue that a strong 'hand' from both the national government as well as the EU is needed in order to improve existing bio-based value chains and discover new ones (HCSS and TNO, 2011). The focus of (inter)national policy should mainly lie in the area of a level playing field for new technologies and to stimulate their use.

4.3.2. Growth in employment

Next, as we have already seen the current employment level in the bio-based industry in the Delta, it is interesting to assess the growth towards this point. In the current firm databases, there is only a limited amount of data on employment in earlier years available. This gap is caused by a number of reasons. First, as stated in the previous paragraph, many of today's firms active in the bio-based economy have only recently started their business. Second, not many companies have always enclosed their previous year results (no obligation?). For example, employment data from the year 2003 is only available at 5 firms (and not at all firms that were already active in that year). Therefore, figure 9 only includes years 2007 and 2011 and embodies only 100% bio-based firms for which data was available, including start-ups.

For the total number of bio-based firms, there are too many fluctuations in data availability at the large chemical companies that comparing the two years would not add any additional relevant information to the results. The results would be severely skewed by missing data in either 2007 or 2011. This will lead to blurred figures from which no proper conclusions can be drawn.

Figure 9: Growth of employment in 100% bio-based firms



A comparison that can be made is with the growth in sectoral, port and total employment in the Delta. As done with cluster size, regional figures can be used to place the growth of the bio-based economy into perspective. This can be done for employment growth in the region (table 18).

Table 18: Employment growth in the Delta

Employment	2007				2011			
	No.	% port	% agro/ind.	% total	No.	% port	% agro/ind.	% total
100% bio-based employment	316	0.15%	0.03%	0.01%	570	0.28%	0.07%	0.01%
Port employment	214035		23%	4%	204302		26%	4%
Agro, industrial employment	940400			19%	794100			16%
Total employment	5040200				5023400			

Source: Eurostat, Havencarriere.nl, PoR, Vlaamse Havencommissie

As one may observe in figure 9, there have been more people employed at 100% bio-based firms in recent years. There are a number of reasons that are likely to have caused this

growth in the sector. First of all, from around 2005 onwards, we have seen a growing pattern in the number of firms that are active in the bio-based industry. This is especially noticeable amongst 100% bio-based firms. Second, as R&D progresses, biomass and its conversion into products have more and more applications today than a number of years ago. In addition, some products have been increasingly popular among consumers or firms. Good examples are biodiesel/bio-ethanol, which can be used in cars, and bio-plastics instead of oil-based products. This consumer-side of the bio-based economy is also expected to grow over the next decade.

When comparing the growth in employment against regional statistics, the growth in the sector becomes again visible. As can be read in table 18, the relative importance of 100% bio-based companies compared to agro/industrial employment has about doubled in four years' time (0.03% to 0.07% respectively). However, one has to be careful with the interpretation of these (relative) numbers as the apparent growth might in fact be a decline of other sectors due to e.g. the economic crisis. This might be the case for agro and industrial employment, which has experienced a real decline of 150.000 people. This might be the real reason for the rise in importance of the bio-based sector in terms of employment. The same holds for the comparison to port employment, which as a whole has also been subject to a decline in FTE.

5. Concluding remarks

5.1. Conclusion

This study has tried to provide more insights in the functioning and performance of the bio-based cluster in the Flemish-Dutch port Delta. The notion of the bio-based economy is still relatively young and has come under great attention at different levels in both the public and private sector. This has also been shown by different policies that have been developed by the EU and national governments. It appears that in the area roughly between the ports of Antwerp and Rotterdam, called the Flemish-Dutch port Delta, various initiatives related to this new type of industry are undertaken. Many agree on the potential of this new sustainable way of manufacturing products or generating energy. Based on these reasons, it has become relevant to measure the performance of the bio-based economy in the Delta. This has been done by assessing the location, size and growth of the bio-based cluster in the Flemish-Dutch port Delta. A logical process has been followed while conducting the study. Reviewing existing literature on the functioning of clusters and performance measures have led the way to a number of appropriate indicators for the analysis. The (few) papers that have been written on the bio-based economy have been used in determining the boundaries of the study and to place the results into perspective. This approach has led to the following steps and conclusions.

From theory, it is known that one can analyse the performance of ports in various ways. Here, we regard the port in its industrial function which needs other indicators than the port as a node in the transport chain. Using earlier academic work on the role and functioning of clusters, it becomes clear that measuring cluster performance is not always straightforward and that the choice of indicators may sometimes differ.

For this study, the functional and geographic boundaries of the bio-based cluster in question had to be determined. There have been no particular bio-based activities excluded, which has been suggested as an option by other scholars. The geographic area has been limited to the six provinces that together form the Flemish-Dutch Delta network. Using the availability of the data of bio-based companies as an important factor, three main performance indicators were identified to be appropriate for this research. FDI, employment and new business formation, in addition to the number of firms and their location are the main indicators that have been extracted to use in the analysis.

With regards to the location of the cluster, it has been shown that most interaction takes place at a lower level than the Delta as a whole, e.g. within smaller clusters such as Biopark Terneuzen. Surprisingly, the ports of Rotterdam and Antwerp only play minor roles in this respect, as they mainly host traditional (petro-) chemical or storage companies. Instead, the

ports of Ghent and Terneuzen host more innovative or 100% bio-based firms that for example share circular links (e.g. through smart waste management).

The size of the bio-based cluster has been analysed using four aspects: number of firms, employees, FDI and mutual relationships. About one-third of all bio-based companies in the dataset our located in one of the four smaller clusters. A second important finding was that most companies are active in the third phase of the bio-based process, related to bio-based products and bio-based energy. A likely explanation is that a large range of products can be made out of biomass feedstock. In addition, most value added is generally found in the manufacturing of bio-based products. Concerning employment, it has been shown that the minority of people employed by the bio-based industry works at 100% bio-based firms. These companies are generally small compared to the large (industrial) multinationals in the dataset. When comparing with regional statistics, it becomes apparent that the bio-based economy as a whole is still a relatively insignificant sector in terms of contribution.

The most noticeable finding of the growth analysis of the bio-based economy in the Delta is the young age of many of the firms that are active in the industry. The majority of firms was founded after 2000 and from 2005 onwards, the rise of the bio-based industry has been clearly visible. A growth pattern can also be found when looking at the employment figures.

5.2. Limitations and recommendations

In analysing the performance of the bio-based cluster in the Delta, a logical approach has been followed in order to arrive at a set of performance indicators. However, for several reasons, the analysis and the results from this study could be improved.

First, in order to improve the current analysis, more data has to become available in order to fully grasp the functioning and performance of the bio-based firms and institutions located in the Delta. Information about cluster size should preferably include more relevant and advanced indicators to assess financial performance or innovation. For cluster growth, it is important to monitor the total amount of firms and employees over multiple years in order to arrive at a more trustworthy growth assessment.

Second, consistency and completeness in the firm databases would be of great help for future research in this field. For many companies included in the dataset, information for the used performance indicators was lacking. Finally, because the bio-based economy is a relatively new concept and involves different sectors, there is no specific industry code available. Having such a code would make a search into the businesses active in the industry a lot easier and more trustworthy.

Being so (potentially) relevant for the economy, the current status of the bio-based industry and its developments should be assessed periodically. In addition to updating this type of research in the coming years with the here used performance indicators, it would be interesting to add some more variables to this type of study. As could be read in previous literature on clusters and their performance, innovation (and patenting), survival rates and the ease of acquiring capital could also be informative indicators for the performance of bio-based clusters.

Having said this, it should be stressed that the lack of data is also caused by the current relatively early stage of the bio-based economy. This means, for example, that there are currently less than 100 firms active in the bio-based cluster in the Delta. Despite a number of policy initiatives by e.g. Agentschap NL or the EU, research by several scholars and knowledge institutes such as TNO have come to the same conclusions as this study. All these results indicate that both the absolute and relative size of the bio-based economy are small. Therefore, it appears that the current amount of policy making and stimulation from governmental bodies cannot be immediately translated in a flourishing new sector. Rather, it can be expected that it will take at least a few more years before the bio-based economy will play a significant role in the wider economy. When the bio-based economy will increase in size, it will be likely that measuring its performance becomes easier. This could be due to e.g. more quantifiable and better measurable information.

I suspect that the bio-based economy as a part of the current 'Topsector' policy has the potential to become an important pillar of the (regional) Dutch economy. The proposition of the Delta with its good connections and strong agro and industrial functions is a strong one, also to foreign companies that are active in these sectors. However, in order to really stimulate the bio-based economy and to be able to fully grasp its benefits in the near future, much more has to be done than just the many documents and initiatives mentioning the upside potential of the bio-based economy. Following the expert's advice from a.o. TNO and the Working Group BBE 2.0 in combination with my own findings has led to my believe that policy should be matched by substantial investments. Only then, the transition will really get underway and the bio-based economy can become a realistic alternative for conventional ways of production.

6. References

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7. Appendix

7.1. Appendix 1: List of bio-based firms in the Flemish-Dutch port Delta

Name	Category	Product	Stage	Address	Location	Cluster
ABENGOA BIOENERGY NETHERLANDS B.V.	Private Company	Bio-ethanol	3	Weena 294	Rotterdam	
AF&F B.V.	Joint venture	Manufactures bioreactors for algae	1	Nijverheidsweg 24	Hendrik Ido Ambacht	
Aiforo	Private company	Conversion (new) wet biomass conversion technqiue + advice	2	Plasticslaan 1	Bergen op Zoom	GCC
Alco Biofuel	Private partnership	Bio-ethanol	3	Pleitstraat 1	Ghent	Gbev
ALGAELINK N.V.	Private Company	Production of algae + equipment for producing algae	1,2	Industrieweg 21	Yerseke	
Alpha Enzymes	Private company	Biobased chemicals	2,3	Plasticslaan 1	Bergen op Zoom	GCC
Arjazon Uienhandel B.V.	Private company	Biomass (onions)	1, Circular	Adriaansweg 1	Kruiningen	
Avecom	Private company	Waste water treatment	Circular	Industrieweg 122	Ghent	
Bewa Groep	Private company	Green energy/biodiesel	3	Appelweg 6	Moerdijk	
BIO BASE EUROPE	Joint initiative	Center for bio-based innovations	Other	Zeelandlaan 2	Terneuzen	Biopark
BIO BASE EUROPE PILOT PLANT	Joint initiative	Center for bio-based innovations	Other	Rodenhuize-kaai 1	Ghent	Gbev
Bioclear	Private company	Consultancy and research	Other	Plasticslaan 1	Bergen op Zoom	GCC
Biofutura	Private company	Biobased packaging	3	Van Nelleweg 1	Rotterdam	

BIOHART B.V.	Private Company	Bio(based) plastic	3	Rondweg 55	Uden	
Biomoer	Joint venture	Biogas + heat/energy	3	Luienhoekweg 3	Moerstraten	
Bioro	Joint venture	Biodiesel	3	Moervaartkaai 1	Ghent	Gbev
BioTorTech	Private company	Biomass conversion technique / Torrefaction technology	2	Plasticslaan 1	Bergen op Zoom	GCC
BIRD ENGINEERING B.V.	Private Company	R&D for new conversion techniques	2	Marconistraat 16	Rotterdam	
BSC Biochemicals	Private company	Enzymes for food and pharma	3	Zwaarveld 41	Hamme	
C2Circle	Private company	Biorefining	2	Canadaweg 1a	Halsteren	
Capricorn	Private company	Venture capital fund	Other	Lei 19/1	Leuven	Gbev
Cargill (BE)	Private company	Inputs for industrial prod./biodiesel	1,3	Moervaartkaai 1	Ghent	
Cargill (NL)	Private company	Alcohol (3) - Water, starch, steam and heat (circular)	3, Circular	Nijverheids-straat 1	Sas van Ghent	Biopark
Catchbio	Joint initiative	Research in development of biomass applications	Other	Postbus 93460	Den Haag	
CLEA TECHNOLOGIES B.V.	Private Company	Enzyme technology	2	Delftechpark 34	Delft	
Clean Minerals Bio Energy B.V.	Private company	Bioelectricity from "mest"	3, Circular	Notelstraat 49	Esbeek	
Colsen	Private company	Biogas from waste	3	Kreekzoom 5	Hulst	

Comgoed	Private company	Houtpellets/biomass	1	Oudelandsedijk 4	Dirksland	
COSUN BIOBASED PRODUCTS B.V.	Private Company	Bio-based chemicals/products	3	Borchwerf 3	Roosendaal	
Cosun Food Technology Centre	Private company	Research in circular economy	Other	Oostelijke Havendijk 15	Roosendaal	
CRADLE CROPS B.V.	Private Company	Growing elephant grass as biomass	1	Graafjansdijk A 84	Westdorpe	
Crustell	Private company	Biobased products on basis of agricultural waste	3	Kortsteekter-weg 57a	Alphen aan den Rijn	
DEN OUDEN GROENRECYCLING B.V.	Private Company	Supply of biomass	1, Circular	Hermalen 7	Schijndel	
Desmet Ballestra	Private company	Production of plants and production processes	2,3	Minervastraat 1	Zaventem	Gbev
Dow Benelux	Private company	(Biobased) chemicals	3	Herbert H. Dowweg 5	Hoek	Biopark
DS fibres	Private company	Fibres from natural products	3	Hoogveld 90	Dendermonde	
DSD Betaprocess	Private Company	Hydrolyse technology	2	Choorhoekse-weg 8b	Wemeldinge	Biopark
DUPONT HOLDING NETHERLANDS B.V.	Private Company	Chemicals	3	Baanhoekweg 22	Dordrecht	
Eco Treasures	Private company	Oils for food/cosmetics industry	3	Moortelstraat 17	Lokeren	
Eco-Energy Oischot	Private company	Biogas plant	3	Broekstraat 31	Oirschot	
Eco-point	Private company	Bio maintenance oils	3	Canadaweg 28	Halsteren	
Ecoservice-Europe	Private company	Biomass transport + supply	1	Oude Haven 44	Oostburg	Biopark

ECOSON B.V.	Private Company	Energy products from byproducts	3, Circular	Kanaaldijk Noord 20-21	Son en Breugel	
EcoSynth	Joint venture	Chemical R&D (sustainable)	2	Stationsstraat 123	Ostend	
Ecover	Private company	Cleaning products	3	Industrieweg 3	Malle	
EDF Luminus	Private company	Heat	3	Buitenring-Wondelgem 10	Ghent	Gbev
Electrabel	Private company	Bio-electricity	3	Energiestraat 2	Ghent	Gbev
Electrawinds ReFuel / Greenfuel	Private Company	Energy/ Biodiesel	3	Oostkade 4	Sluiskil	Biopark/ Gbev
EPZ	Private company	Electricity plant --> also biomass/coal fired pplant	3	Zeedijk 32	Borssele	
Fargate	Private company	Technology to use waste water for algae / Algae installations and trading	1,2, Circular	Veerstraat 18	Oud-Vossemeer	
Franken Inox BV	Private company	Algaereactor production	1,2	Monsterweg 64	Borssele	
Genencor	Private company	Biomass conversion	2	Komvest 43	Brugge	Gbev
HAYNEST B.V.	Private Company	Bio-based packaging material	3	Van Thienenlaan 5a	Eindhoven	
Heros Sluiskil	Private company	Waste recycling / biogas, biodiesel	3, Circular	Oostkade 5	Sluiskil	Biopark
ICL-IP Terneuzen	Private company	Bromine and recycling	Circular	Frankrijkweg 6	Terneuzen	Biopark
LambWeston	Private company	Biogas from restproduct of potato's	Circular	Stationsweg 18a	Kruiningen	
Lijnco Green Energy	Private company	Biobased gas+electricity	3	Oostkade 5	Sluiskil	Biopark

Millvision	Private company	Consultancy and research on bio-based activities/innovations	Other	Plasticslaan 1	Bergen op Zoom	GCC
NESTE OIL NETHERLANDS B.V.	Private Company	Renewable diesel	3	Antarcticaweg 185	Maasvlakte Rotterdam	
NETTENERGY B.V.	Private Company	Energy and materials from biomass	3	Torenpad 48	Boskoop	
NNRGY B.V.	Private Company	Elephant grass as form of biomass	1	Burgemeester van der Jagtkade 41	Hellevoet-sluis	
NOVA LIGNUM B.V.	Private Company	Bio-based wallcovers for housing etc.	3	Hazeldonkse Zandweg 97a	Zevenberg-en	
Oiltanking	Private company	Storage of biofuel	3	Moervaartkaai 12	Ghent	Gbev
Oleon	Private company	Biochemicals	3	Assenedestraat 2	Ertvelde	Gbev
OWS	Private company	Building bioplant, R&D, waste management	2	Dok Noord 5	Ghent	Gbev
PANTANOVA B.V.	Private Company	Fiberhemp as biomass input	1	Huub van den Brulestraat 50	Rotterdam	
PLANT ONE B.V.	Joint initiative	Test facility for sustainability processes	Other	Merseyweg 10	Botlek Rotterdam	
Plastic Company	Private company	A.O. bioplastics recycling	Circular	Industrieweg 19	Oudenbosch	
PRISNA B.V.	Consortium	R&D in new production techniques	2	Steenoven 7	Oostvoorne	
Progression Industry	Private company	Biodiesel	3	Plasticslaan 1	Bergen op Zoom	GCC
Proviron	Private company	A.o. biodiesel	3	Stationstraat 123	Ostend	

PURAC BIOCHEM B.V.	Private Company	Chemicals (mostly biobased)	3	Arkelsedijk 46	Gorinchem	
Retoplast	Private company	Biobased plastics	3, Circular	Plasticslaan 1	Bergen op Zoom	GCC
Rodenburg Biopolymers	Private company	Bioplastics (biopolymer)	3	Denariusstraat 19	Oosterhout	
Rubia Natural Colours	Private company	Natural colours/paints	3	Prins Reinierstraat 10a	Steenbergen	
S.E.S. International	Joint venture	Biodiesel	3	Appelweg 6	Moerdijk	
SABIC Innovative Plastics	Private Company	Chemical products	3	Plasticslaan 1	Bergen op Zoom	GCC
Sagro	Private company	Waste recycling	Circular	Ameliaweg 1	Westdorpe	Biopark
Sea-Invest	Private company	Storage of raw materials	1	Skaldenstraat 1	Gent	Gbev
SOLTENS B.V.	Private Company	Reprocessing of byproducts	3, Circular	Kortsteekter-weg 57a	Alphen aan den Rijn	
STICHTING KENNISCENTRUM PLANTENSTOFFEN	Institution	Knowledge institution	Other	ABC Westland 128	Poeldijk	
Storaenso	Private company	Biomass producer	1	Wondelgem-kaai 200	Ghent	Gbev
Suiker Unie	Private Company	Biogas	Circular	Noordzeedijk 113	Dinteloord	N-Prinsenland
Synbra Technology/Biofoam	Private company	Bio Polymer (PLA) a.o.	3	Zeedijk 25	Etten-Leur	
The Bioplastic Factory	Private company	Bioplastics	3	Chr. Huygensstraat 3	Oud-Beijerland	
United Gas	Private company	Liquid Bio Gas	3	Canadaweg 1a	Halsteren	
Van Alphen	Private company	Biogas from biomass	3	Seijdlitzstraat 2	Axel	

VAN BERKEL BIOMASSA & BODEMPRODUCTEN B.V.	Private Company	Biomass and waste management	1, Circular	Marniersstraat 4	Uden	
Vatricom	Private company	Biomass and pallet production	1	Slikkenburgse-weg 8	Halsteren	
WarmCO2	Joint project	Heat and CO2 for agriculture	Circular	Schelpenpad 2	Terneuzen	Biopark
Yara	Private company	Fertilizers	Circular	Industrieweg 10	Sluiskil	Biopark