Open Government Data and Circular Business Models – Friends or Foes?

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ABSTRACT

This study investigates the relationship between open government data and the circular economy, as the former is currently mainly related to social, economic and political benefits, but not yet to environmental ones. Despite the underdeveloped relationship, open government data could provide valuable insights for companies, providing the necessary information for the development of a circular business model. Therefore, this research aims to establish the connection between the two, investigating whether the utilization of open government data promotes circular business models. The results of the regression analysis, which only partially supported the hypothesis, indicate that further research is needed into the optimal use of open government data and the appropriate data to foster the development of circular business models.

INTRODUCTION

Our world is filled with data, and since the boom of the internet in the 1990s it follows an exponential growth leading to the duplication of the global datasphere each second year (Ben Hemo, 2020). This increased need for data arose hand in hand with increasingly powerful calls for enlarged transparency through, for example the 'right to information' movement, promoting public access to information from a human rights perspective (Ubaldi, 2013). As a result, many governments across the world, such as the Dutch, began to adopt open government data (OGD) policies (Ruijer & Meijer, 2020). OGD is data collected and transformed into meaningful formats by the government which is then published, granting access to the public for re-use (Ubaldi, 2013). Even though the direct impacts of releasing OGD are still not fully understood, it is hoped, that through the increased amount of information available, decision-making can be improved and thus, a positive effect on political, economic, and social factors can be achieved (Granickas, 2013). Benefits such as new job potential, improved decision-making and growth of markets using the provided data are attributed to the increased transparency and wider access to relevant information for the public (Granickas, 2013). However, such value can only be generated if OGD publication leads to a shift in the relationship between governments and external stakeholders, such as private actors, toward close cooperation and information sharing between the parties (Jetzek, Avital & Bjørn-Andersen, 2014). The higher the degree of participation and collaboration of stakeholders in the value generating process, the larger the available database and the higher the likelihood of moving beyond efficiency and transparency towards generating innovative and participatory solutions that have the potential to solve economic and/or societal problems (Jetzek et al., 2014).

Efficiency, transparency, collaboration with stakeholders, and innovation are also valuable strategies when it comes to the implementation of sustainable practices (Hart, Milstein &

Caggiano, 2003). Such sustainable practices are defined along the triple bottom line which entails the inclusion and pursuit of social, environmental, as well as economic goals (Hart et al., 2003). Achieving said goals requires intensive stakeholder collaboration, not only to generate valuable inputs from outside the organization, but also to mitigate risks related to the process of creating sustainable value (Hart et al., 2003; Gast, Gundolf & Cesinger, 2017).

Even though the increased provision of OGD and the shift towards sustainable practices occur simultaneously, environmental benefits are hardly mentioned when it comes to the benefits of OGD. The focus lies on the economic, political, and social benefits that can be achieved through innovation generated by using OGD (Jetzek et al., 2014; Granickas, 2013).

When it comes to the preservation and restoration of environmental value, one quickly reaches the concept of circularity (Murray, Skene & Haynes, 2017). The circular economy is based on two cycles; the biogeochemical cycles which form the basis of life on earth as every molecule passes through several cycles throughout its life; and recycling, the concept of reusing material inputs repeatedly, thereby preventing waste (Murray et al., 2017). Those cycles are not only narrowed down or closed but also intensified and dematerialised, making companies adopting a circular business model more resource efficient than their non-circular counterparts (Geissdoerfer, Morioka, de Carvahlo, Evans, 2018). As such, the circular economy is opposing the current economic system which has led to linear consumption (Gupta, Chen, Hazen, Kaur, Santibañez Gonzalez, 2019). Linear consumption means that products are created from non-renewable resources which are then consumed by individuals and disposed of at the end of their useful life without recycling or reusing the resources used (Gupta et al., 2019). To move away from linear consumption, systemic change is required.

The issue with systemic changes towards the circular economy is that several factors play into the successful implementation of more circular business models. The two major factors

identified, are data analytics and stakeholder engagement (Gupta et al., 2019). Only through extensive analysis of available data and through close cooperation with stakeholders the needed efficiency in operations can be achieved to eliminate waste, move beyond a linear consumption model and become 'truly' circular (Gupta et al., 2019). The data that is particularly important for the development of a circular organization and is provided by the Dutch OGD initiatives is data on customer behaviour and system performance (Luoma, Tappinen, & Pentlinen, 2021; Overheid, 2021a). Here, the former refers to the behaviour of potential customers in regard to their overall use of commodities and their consumption choices, providing insights into how companies can fill needs efficiently and effectively, while the latter, relates to the functioning of the overall economic and socio-political system the companies operate in, providing insights into how resources can be used efficiently and how to optimize operations (Luoma et al., 2021). This includes for example; waste management, developments in the labour market, or topographic information.

To successfully manage decisions involving various stakeholders, analysing data effectively and employing the long-term perspective of circularity, organizations aiming to become circular thus need to make informed, high-quality decisions which is one of the assumed benefits of OGD (Granickas, 2013). Because of this need for increased amounts of data and collaboration, as well as improved decision-making, one could assume that circularity is linked to the utilization of OGD. However, similar to the connection with environmental factors, there is little evidence that connects the circular economy and OGD. Because of this underdeveloped link between two concepts arising simultaneously, this research will attempt to establish such a connection by answering the research question: *To what extent does the utilization of open government data stimulate the development of circular business models?*

Answering this question will extend our knowledge with regard to the benefits of OGD while also yielding implications for practice. By having evidence for a connection between the utilization of OGD and circular business models, policy-makers will be more inclined to provide said data. This holds especially true in light of the Dutch government publishing a National Action Plan for both; circularity and OGD (The Ministry of Infrastructure & the Ministry of Economic Affairs, 2016; Ministry of Interior and Kingdom Relations, 2015).

In the next sections the theoretical background of this research is outlined, followed by the methods that were used to gather data on the research question. After that, the results of the questionnaire used will be laid out and discussed in light of the existing theory.

THERORETICAL BACKGROUND

Open Government Data

Open government data (OGD) is a tool that governments can use to become more transparent and empower their citizens to create economic, social and political benefits. It is data published by the government in an attempt to increase public participation and collaboration (Ubaldi, 2013). However, not any data published by the government can be considered OGD. Certain principles must be adhered to, for the public to be able to make effective use of the data (Ubaldi, 2013). The principles entail that the data published must be: complete, primary, timely, accessible, machine-processable, non-discriminatory, non-proprietary, and license free (Ubaldi, 2013). Thus, data collected by the government must be made publicly available in its entirety as quickly as possible without someone claiming exclusive control over it and in a manner that allows automated processing without the need to purchase access or analyse the data oneself (Ubaldi, 2013). Only if those principles are fulfilled, the impact of OGD can occur (Granickas, 2013).

One major form of impact of OGD is efficiency and innovation that can be achieved through its use (Jetzek et al., 2014). Through re-using the provided data, civilians and organizations can achieve advantages as their decision-making can be improved through the enlarged amount of data available (Granickas, 2013). OGD includes reports and statistics on the status quo within the country of publication but also on relations between countries (Ministry of Interior and Kingdom Relations, 2015). Using this data can lead to social and economic benefits through the creation of new businesses, as well as increased efficiency in operations and empowerment which can be achieved by identifying inefficiencies in the current economic, political or social system and by analysing the behaviour of the respective countries' civilization which could be potential customers (Granickas, 2013).

However, the implementation of OGD also comes with challenges. These are challenges that generally arise with the sharing of information and technology such as privacy and data security, information overload, or the formation of a digital elite, but also political challenges such as blurred accountability, the cost of collecting data, and the danger of data mis-use (Ubaldi, 2013). Therefore, the establishment of a legal and regulatory framework that tackles these challenges and provides relevant guidelines to the publication of OGD are essential (Ubaldi, 2013).

In summary, OGD is data that has been made available for public use by the government to enhance civic participation, but also to serve as a strategic resource to organizations for the creation of social and economic benefits.

The Circular Economy

As one of the frontrunners of economic re-thinking, Stahel (1982) introduced the idea of loops in which material and energy usage is minimized, thereby extending the useful life of products. Closed-loop systems are still relevant today and appear under various different terms, such as

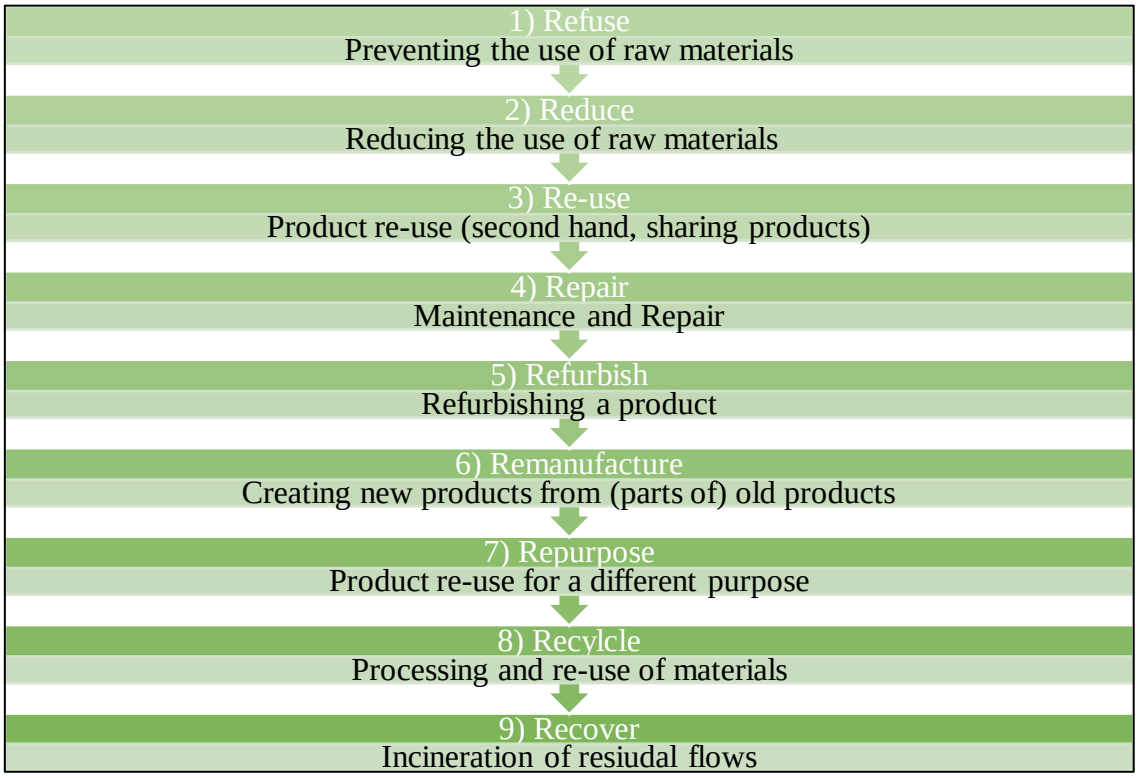
cradle-to-cradle (McDonough & Braungart, 2002) or resource cascading (Pauli, 2010). Closing the loop means a 'synergistic integration of production activities at different stages of a production cycle where waste […] of one level may be used as input material for the next' (Gupta et al., 2019). This contributes to the overall goal of the circular economy of restoring the natural balance, as it minimizes waste and returns nutrients to the natural cycle (Murray et al., 2017; Gupta et al., 2019).

The most common definition of the circular economy to date follows the 4R framework, focusing on reusing, recovering, recycling and reducing the raw materials used in the production of a product (Kirchherr, Reike, Hekkert, 2017). However, as this framework cannot capture the whole spectrum that is required to not only make effective use of materials, but to also extend the lifespan of products, and create smarter product uses and ways of manufacturing a product, the approach was extended to the 9Rs approach (Kirchherr et al., 2017). The 9Rs approach focuses on what is deemed a more complete approach to the circular economy, as it entails not only the manufacturing of the product through reducing and reusing materials, and the end-of the product's useful life through recycling and recovering the materials, but also on the steps in-between (van Buren, Demmers, van der Heijden, Witlox, 2016). As the 9Rs frameworks provides a more complete overlook over the various practices needed to establish a circular economy, it will be the guiding framework throughout the following sections (Figure 1).

Thus, the circular economy can be defined as a model of production and consumption that aims to restore the natural balance through the elimination of waste from the product life cycle.

FIGURE 1

The 9Rs framework



(van Buren et al., 2016)

Circular Business Models

Circular business models (CBMs) are developed to implement the circular economy by closing a company's resource loops and thus, minimize waste and overall resource utilization (Geissdoerfer et al., 2018). Geissdoerfer et al. (2018) state, that to successfully implement CBMs three elements are needed: sustainable value creation, pro-active management of a more comprehensive set of stakeholders, and a long-term perspective. The creation of sustainable value occurs at each stage of the product life-cycle. Already in designing the product, significant steps have to be made to assure that the 9Rs of the circular economy can be undertaken later (Murray et al., 2017). The product is designed to be 'futureproof' which means it can be used for longer and also lasts longer (van den Berg & Bakker, 2015). Naturally, in the

manufacturing of the product, as little resources as possible are used and the product is produced to enable disassembly, maintenance services, and the re-use of its parts in the following steps (van den Berg & Bakker, 2015). The production and re-use of such products also entails a vast service network as not only the primary delivery to the customer must be ensured, but also reverse logistics are needed to return the product to the manufacturer at the end of its useful life or when recycling or repair services are needed (van den Berg & Bakker, 2015). Due to the various considerations that need to be made throughout the design of a circular product or service, these offerings tend to be more complex, meaning that more information is required to assess the best potential materials, suppliers, and stakeholders (Schmitt & Hansen, 2018). This in turn means that a higher degree of absorptive capacity is required for the development of circular business models, enabling the companies to make the right decisions (Schmitt & Hansen, 2018). Furthermore, the entire process requires pro-active stakeholder management as most companies cannot design, produce, distribute, repair, and recycle a product by themselves (Geissdoerfer et al., 2018). Close cooperation, as well as coordination between partners is needed to optimize the production process and prevent negative externalities (Gupta et al., 2019). Not only the prolonging of a product's life, but also the stakeholder cooperation requires a long-term perspective, the third core element of circularity. This is because supply chains and production cycles need to be integrated, which requires time for adaptation for all stakeholders involved (van den Berg & Bakker, 2015). Furthermore, the preservation of resources ensures that future generations will be able to enjoy those resources as well; an aspect which shows that organizations with a CBM look beyond short-term goals and respect future generations' needs (van den Berg & Bakker, 2015). To create a circular business, vast amounts of information are thus required to ensure that the products or services created are futureproof, effective stakeholder collaboration is established, and a long-term perspective is employed.

This process sets CBMs apart from their linear counterparts as distinct importance is put onto the prevention of waste and ploughing resources back into the system (Gupta et al., 2019). It moves away from the 'take-make-consume-throw away' pattern and toward the 9Rs framework (European Parliament, 2020). Where linear business models relied on cheap, easily accessible materials and energy, CBMs focus on using as little diverging materials as possible, which are of high quality and recyclable (European Parliament 2020; van den Berg & Bakker, 2015). In doing so, CBMs can make substantial savings with regard to externalities, natural resources, but also financial resources.

Open Government Data and Circular Business Models – a Theoretical Framework

OGD and the circular economy are important concepts of our time that are continuously gaining importance. Both require stakeholder engagement to be implemented, meaning that close cooperation and coordination, as well as extensive communication are needed (Jetzek et al., 2014; Geissdoerfer et al., 2018). To manage such stakeholder engagement, CBMs need timely and relevant information to improve decision-making and streamline decisions among involved parties and assure that collective actions are undertaken (Gupta et al., 2019). Information regarding system performance and consumer behaviour is especially valuable for CBMs as such data can aid them in understanding their customers as well as the overall environment of its supply chain better (Luoma et al., 2021). As not every business has the capability for extensive, ongoing data collection and analysis, OGD can be a valuable source to gain first insights into the behaviour of potential customers and the overall workings of the economic and social system. The, timely, accessible, and machine-processable nature of OGD facilitates its use in a resource efficient way, allowing firms to gather such initial insights without the need for collecting data themselves (Ubaldi, 2013). Furthermore, data collected by the government might also be more representative than data collected by individual companies

as more large-scale observations can be made (Luoma et al., 2021). This representative nature of OGD on the other hand, also means that the data is not tailored to the specific needs of individual companies as the government cannot collect data on specific customer groups due to privacy concerns and the overall scope of governmental operations (Ubaldi, 2013). Despite, this and as previously mentioned, OGD could provide valuable initial insight for companies which aim to develop a CBM. Therefore, it seems logical to assume a positive connection between OGD and the development of CBMs. However, it is also important to note, that the two main requirements for CBMs, namely stakeholder engagement and an intensified need for information are less important for conventional, linear business models due to the inherent complexity that is part of most CBMs because of the pursuit of environmental (and sometimes social) goals next to economic ones (Jetzek et al., 2014; Geissdorfer et al., 2018; Gupta et al., 2019). The sole focus on economic goals of linear business models, makes stakeholder involvement and data on system performance and consumer behaviour, less essential for linear businesses models. Therefore, it follows:

Hypothesis 1: The systems performance and consumer behaviour insights provided by open government data, are more valuable for the development of circular business models than that of linear ones.

Researching the connection between the circular economy and big data, Gupta et al. (2019) found that the implementation of CBMs is facilitated through insights derived from data analytics as they can enhance the quality of predictions and decision-making. This holds especially true in regard to the resource optimization and stakeholder engagement, meaning that CBMs are particularly reliant on data regarding system performance and customer behaviour for their development (Luoma et al., 2021). However, as the development of a CBM is often a transitional process, requiring many gradual steps towards circularity, consulting said

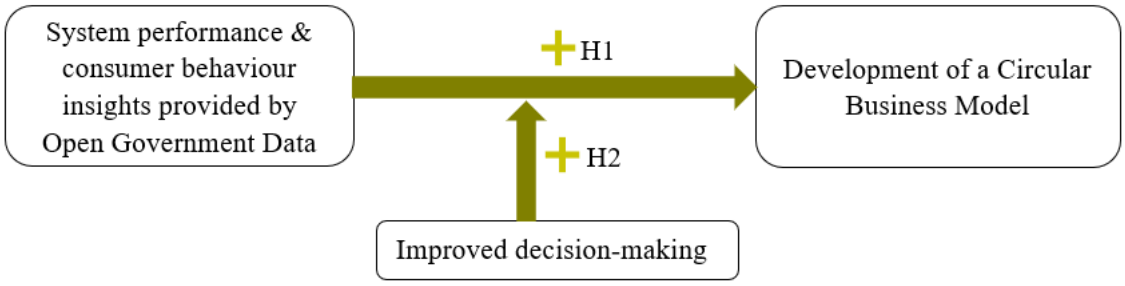
data once will not suffice (Van Buren et al., 2016). This means that the development of a CBM is a process that requires a larger timeframe in which various high-quality decisions need to be made to become more circular (Hofman, 2019).

As improved decision-making is also one of the benefits attributed to the utilization of OGD and even links it to environmental improvements, it seems logical to assume that the improved decision-making created through OGD can facilitate the development of CBMs (European Data Portal, 2020). This notion is reinforced by Delmar, Hoffmann, and Kuss (2011) who found that the degree of absorptive capacity in an organization can determine its environmental proactivity and therefore its competitive advantage in terms of environmental performance. This environmental proactivity can lead into the gradual adoption of more circular practices, as the adoption of a CBM is generally considered an effective pro-environmental strategy (Gusmerotti, Testa, Corsini, Pretner, Iraldo, 2019). As the initiating authors of the absorptive capacity theory, Cohen and Levinthal (1990) state, that absorptive capacity is a detrimental part in a firms' decision-making and the utilization of OGD is said to improve the quality of decision-making, it follows:

Hypothesis 2: The positive impact of open government data on the development of circular business models is reinforced through the improved decision-making triggered by higher utilization of open government data.

CONCEPTUAL MODEL

Hypothesis 1 & 2



METHODOLOGY

Research Design and Method

In order to answer the research question: '*To what extent does the utilization of open government data stimulate the development of circular business models?'* I choose to adopt a quantitative research design using a questionnaire to collect data. Through a quantitative approach, more nuanced differences between respondents can be gathered due to the standardized nature of responses (Bell & Bryman, 2019, chapter 3). Furthermore, the larger sample sizes employed in quantitative research allowed me to make more generalized claims regarding the relationship between the dependent variable, CBMs, and the independent variable, OGD.

Procedures

Case Selection

Conducting this research, I focused on the Netherlands as my theoretical domain. This is because of the country scoring high in both concepts; OGD and circularity, in international

comparisons. This focus on both concepts means that all ventures operating in the Netherlands are working under the same institutional framework and thus, no differences in the sample can occur due to the institutional framework in which the ventures operate. Furthermore, I decided to not limit my research to specific industries as CBMs can occur in various different markets and thus, insights could be gained from all kinds of companies.

With regard to OGD, the Netherlands score among the top 20 countries with the highest degree of OGD (Appendix A). Furthermore, the country actively addressed the implementation of OGD through a National Action Plan in 2015 and increased its provision of OGD to 20,630 datasets since then (as of June 9, 2021) (Overheid, 2021a). The main page mentioned in this action plan is overheid.nl where the aforementioned datasets were published according to the following criteria: the data is presented in a processable format, all data includes at least one working link to further websites, and the owner of the dataset is known (Overheid, 2021b). The data on Overheid is furthermore, also sorted into 17 distinctive categories (Appendix B). Looking at the required information for CBMs, namely customer behaviour and system performance, data can be found in all categories, but particularly in the economy, nature and neighbourhood, space and infrastructure and the board category, where information on consumption patterns, the workings of the economic, social, natural, and political system, as well as the price development of commodities is displayed (Overheid, 2021a).

However, Overheid is not the only website where the Dutch government and affiliate organizations publish data. Another important page of OGD publication is the Centraal Bureau voor de Statistiek (CBS) where statistics with regard to labour and income, the economy, and the society are published under the European Statistics Code of Practice (CBS, 2021).

Similarly to their OGD provision, the Netherlands score in the top 15 in rankings assessing the development of a circular economy in several countries (Appendix C). Also, in this area, the

country has developed an action plan which elaborates on the country's aim to become entirely circular by 2050 (The Ministry of Infrastructure & the Ministry of Economic Affairs, 2016). However, according to the circularity gap report (2021) the Netherlands are currently only 24.5% circular, meaning that the country still has a long way to go to achieve its goal highlighting the need to provide adequate support for companies aiming to develop a CBM.

Sampling

To calculate the appropriate sample size for this research, I relied on the commonly used events per variable (EVP) rule of thumb. The EVP holds that per variable in the model, 10 observations should be made (Peduzzi, Concato, Kemper, Holford, Feinstein, 1996). In case of this research with one independent and one moderating variable, a sample size of 20 is appropriate to create a representative model, without overfitting (Peduzzi et al., 1996). Despite much discussion about this method with regard to its power and oversimplicity, I still decided to apply this method instead of other a priori sample size calculators such as G*power, as the EVP facilitated reaching the desired sample size under the given time and resource constraints of this research (Austin & Steyerberg, 2017).

As the sample was distributed through the networks of various Dutch incubators, through emailing the survey to companies directly, and by distributing it through my personal LinkedIn network, the sampling strategy I pursued was by no means random. This means that I cannot make claims to the overall population of Dutch companies, as my sample will constitute mostly of organizations that participated in an incubator program and organizations that have some online address and could be contacted (Bell & Bryman, 2019, chapter 7). Thus, the chosen sampling strategy resembles a mix of purposive sampling for the part where companies were found online and snowball sampling where 'the researcher makes initial contact with a small

group of people who are relevant to the research topic and then uses these to establish contacts with others' for the incubator and LinkedIn part (Bell & Bryman, 2019, chapter 7).

Data Collection

Data was collected through an online questionnaire which was created using Qualtrics, and was sent via email to potential respondents. The questionnaires were distributed through the network of Dutch incubators who have vast access to ventures of varying industries. Additionally, I also sent out 332 separate emails to companies. Lastly, I utilized my personal LinkedIn network to distribute the questionnaire. The online format of the questionnaire allowed me to reach a wider target group, while simultaneously facilitating responding to the survey for respondents as they could do this at their own time and convenience (Bell & Bryman, 2011, chapter 26).

The questions included in the questionnaire were directed towards measuring whether the company employed a CBM, as well as their OGD usage and the quality of their decision-making. As companies might be in the process of establishing a CBM, it is difficult to determine their business model with a simple yes/no question, which is why I decided to assess circularity through a two-fold approach, which also allowed me to increase the convergent validity of the measures (Bell & Bryman, 2011, chapter 6).

The questions regarding the CBM were closed questions, constituting from a mix of one 0-100 range question and multiple Liker-scale questions. The 0-100 range question allowed respondents to self-assess the degree of circularity in their business model. As self-assessment is prone to self-assessment bias, I verified these insights, by employing Liker-scale questions based on the 9Rs, stakeholder management, and the long-term perspective which are detrimental to CBMs. Hereby, I differentiated between product companies, service companies,

and companies that offer both, to gain insights into all sides of potential circular organizations, as different offerings might imply a different approach to circularity.

In order to verify those results post hoc, I also asked companies to formulate their mission statement, allowing me to determine whether the results of my analysis with regard to the degree of circularity were confirmed by that through specific characteristics. Those characteristics were found through a qualitative, linguistic analysis of circular businesses' mission statements, which according to Babnik et al. (2013), provide significant insights into a firm's organizational culture and hence, into their actions (Appendix C).

Similarly, OGD utilization was measured through Liker-scale questions aimed at the frequency of utilization and the importance of the input generated from OGD.

Lastly, the quality of decision-making was assessed using the Decision-making Quality Scale by Hollen (1994) which is based on the criteria by Janis and Mann (1977), and again measures the variable through a Likert-scale. I decided to use this scale due to its theoretical foundation and its proven reliability (Hollen, 1994). Furthermore, this scale was also found to score high in content and construct validity, meaning that the scale is able to capture the differences in decision-making (Hollen, 1994).

Due to time and resource constraints, it was not possible to measure respondent's utilization of OGD, the quality of decision-making and the degree of circularity in their business model through observations or action research. Thus, I decided to measure the attitudes of respondents regarding those topics, as those are deemed to provide valuable insights in social sciences research (Ornstein, 1998).

Before the questionnaire was send out, I conducted two pre-tests. First, a native English speaker, unfamiliar with the topic, read over the questionnaire to determine whether there are any issues with wording and grammar that make the questions difficult to understand. Second,

I used the cognitive method of think-aloud with two Dutch business owners to further verify the questions (Collins, 2001). I decided to conduct only three pre-tests due to time constraints. By pre-testing the questions, I increased their internal validity as problems with the questions could be detected and improved upon to ensure the highest degree of understanding for the respondents (Collins, 2001).

Data Analysis

Upon retrieving the data, I analysed it using the statistical analysis software Stata. First, I analysed incomplete observations by determining whether the data was missing completely at random, missing at random, or missing not at random. Despite the ongoing debate whether Likert-scale question are to be treated as interval or ordinal, I decided to treat the data as interval as this will allow me to compare the means of the independent variable to the dependent variable (Wu & Leung, 2017). Thus, I calculated the means across the constructs measured through Likert-scales to obtain one value per variable per observation. In order to ensure that I obtain maximum insights from the data gathered, I decided to test both hypothesis two times; once with the dependent variable measured through the Likert-scale and then with the dependent variable measured through the range question. Doing so allowed me to differentiate between respondents self-assessment of the degree of circularity and the assessment of this through Likert-scale questions.

Before the data was analysed, I first tested the reliability of the Likert-scale questions using Cronbach's alpha. Both hypotheses were then tested using a regression analysis which allowed me to determine the effects of each independent variable on the dependent variable (Keller, 2021).

RESULTS

Missing Cases and Non-response

Upon closing the survey after two weeks of data collection, 63 responses were collected. Of those, seven needed to be deleted as they were previews, three for the conducted pre-tests and four were my own previewing of the questionnaire. Of the remaining 56 responses, 26 were incomplete (41%). Due to the anonymous nature of the questionnaire it was impossible to follow-up on those respondents that did not complete the questionnaire and thus, I cannot assume that the data is missing completely at random (van Buuren, 2018). However, as respondents dropped out of the questionnaire at different stages of the survey, I proceeded assuming that the observations are missing at random (Schafer & Graham, 2002). Following Jakobs et al. (2017), the rather high percentage of missing data above the rule of thumb of 40% means that a complete case analysis should be conducted, analysing only complete responses. Despite this, I decided to conduct an additional single imputation analysis with means using those observations which were completed by 50% or more as those cases filled in what type of offering they provide (product, service or both), meaning that it was possible to assign the appropriate mean values to be filled in as single imputation. Five observations were completed by 50% (7.9%). The single imputation analysis of those numbers can be found under 'additional analysis' further below. The following sections on the descriptive statistics and the analysis of hypothesis 1 and 2 are thus, based on the complete case analysis with a sample of 30 responses.

Data Preparation and Initial Tests

Reliability of Constructs

In order to test the reliability of the constructs measured through Likert-scale items, I first calculated a Cronbach's alpha for each of them (Appendix E). As all alphas were above the

threshold of 0.7, the constructs which are used to measure the hypotheses are deemed reliable (Taber, 2017). The high initial alpha value means that no items needed to be excluded from further analysis as all of them contribute to the measurement of the corresponding construct.

Creating Mean Scores

To begin the statistical analysis, I combined the insights generated by various Likert-scale items by calculating the mean for each observation across the constructs, providing a single mean-value for each construct.

Descriptive Statistics

The sample of 30 observations in the complete case analysis was widely distributed not only across the year the companies were founded in, but also in regards to the industry they operate in (Appendix F). Within the entire sample 12 companies are offering a service, while 10 focus on products only, and eight offer both. The most common industry, companies in the sample are in was the agricultural sector, followed by mobility and then technology/software and consultancy/BPO (Appendix F).

Furthermore, to get a broad overview over the main variables used in this research, I created histograms (Figure 2-4). Hereby, the higher the value the more circular, the higher the utilization of OGD and the higher the quality of decision-making. The central tendency as well as the variability of these measures is outlined in Table 1.

Figure 2 depicts the degree of circularity measured through both; the Likert-scale and the 0-100 range question. Both graphs indicate that the majority of the companies in the sample are in the process of becoming circular, engaging in some environmentally-proactive behaviour, but are not yet fully circular. This is confirmed by the means of the measures, being 2.98 for the Likert-scale and 55.1 for the range questions (Table 3). Furthermore, it is also noteworthy

that according to the Likert-scale questions none of the companies are either fully circular of fully linear. However, when looking at the self-assessment of circularity, companies do identify as either linear or circular, as visible through the minimum and maximum values in Table 1. Figure 2 also indicates that the distribution appears to be non-normal, which is confirmed by a skewness and kurtosis test for normality indicating that the degree of circularity is slightly skewed to the right with a skewness of 0.29 and 0.36 and kurtosis of 0.59 and 0.43, respectively, meaning that the dependent variable is not normally distributed.

FIGURE 2

Degree of circularity in the business model

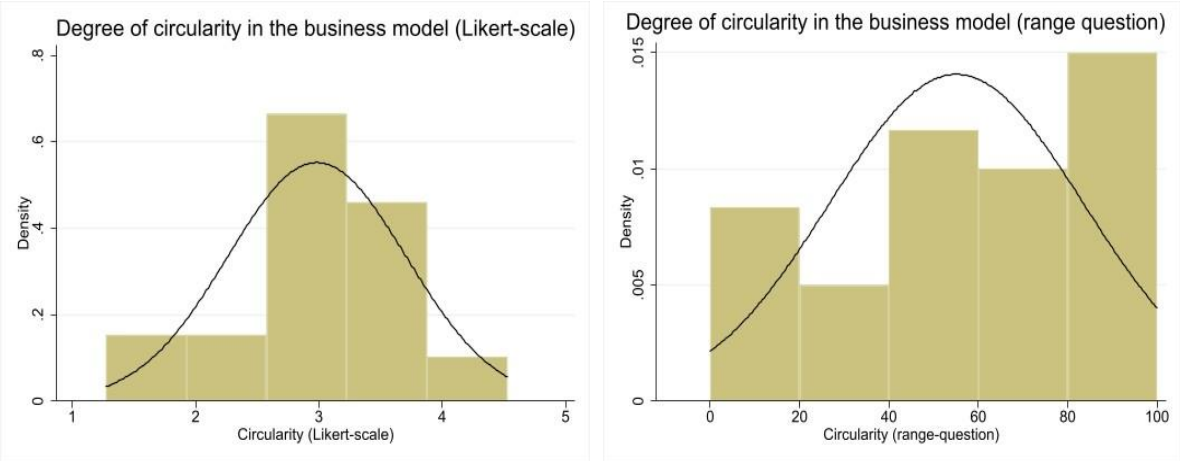
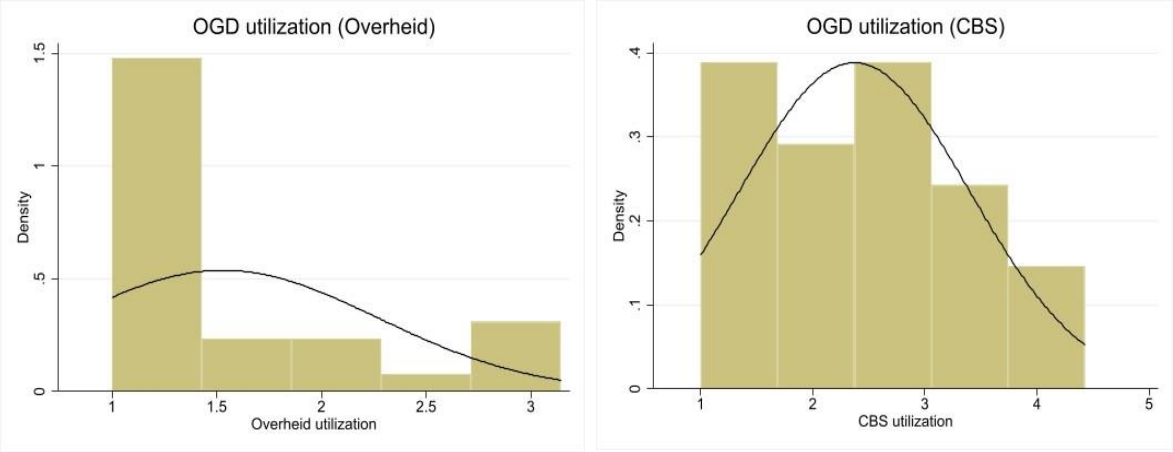


Figure 3 depicts the OGD utilization across both platforms evaluated in this research. It is noteworthy that the CBS seems to be used more frequently than Overheid, even though both score overall rather low with means of 1.53 and 2.37 respectively (Table 1). The skewness and kurtosis tests for both platforms further reveal that neither of the variables is distributed normally (CBS: skewness: 0.99, kurtosis: 0.12; Overheid: skewness: 0.01, kurtosis: 0.46).

FIGURE 3

Open government data utilization



Lastly, the moderating variable (Figure 4), indicates that the quality of decision-making within the sample is rather high, with a mean of 3.92. The skewness and kurtosis test for normality shows a slight positive skewedness of 0.8229, and kurtosis of 0.5123. Thus, also the quality of decision-making is not normally distributed.

FIGURE 4

Quality of decision-making

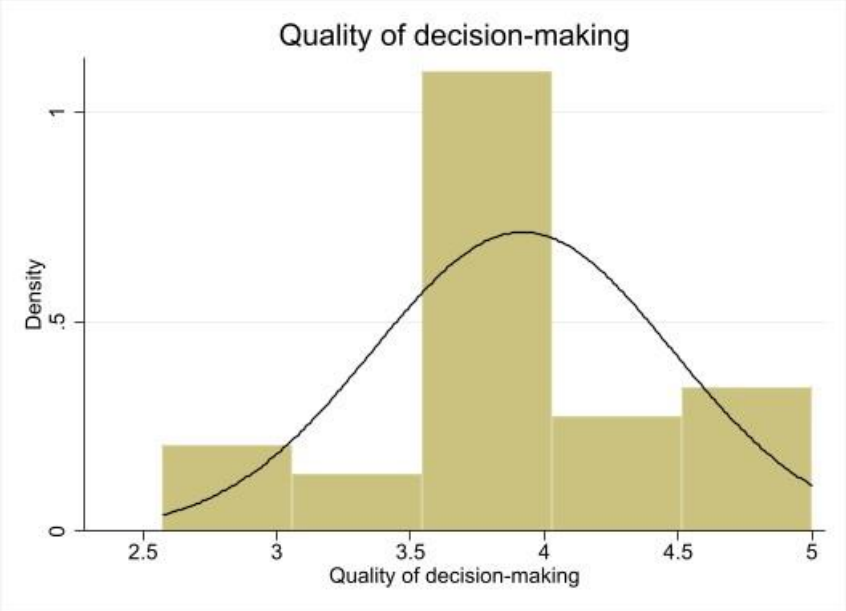


TABLE 1

Descriptive statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Circularity (Likert-scale)	2.98	0.72	1.27	4.53
Circularity (range question)	55.1	28.36	0	100
OGD (Overheid)	1.53	0.74	1	3.14
OGD (CBS)	2.37	1.03	1	4.43
Quality of decision-making	3.92	0.56	2.57	5

Statistical Analysis of Results

Hypothesis 1

To test hypothesis 1: *The systems performance and consumer behaviour insights provided by open government data, are more valuable for the development of circular business models than that of linear ones,* two different tests needed to be conducted. First, I correlated both OGD utilization measures with the degree of circularity in both formats; the Liker-scale and the range question. There appears to be no significant correlation between CBMs and OGD utilization (Likert-scale: Overheid: p-value: 0.96; CBS: p-value: 0.88; Range question: Overheid: p-value: 0.95; CBS: p-value: 0.28)

Despite the insignificant results of the correlation analysis, I proceed with the calculation of the regressions. Both adjusted R^2 are rather low at -0.07 and -0.02 for Likert-scale and range

questions respectively, revealing that only 2% and 7% of variation can be explained by this model, diminishing its explanatory power. Similarly, all F-values of the test are insignificant, indicating that the independent does not really predict the dependent variable (Table 2). This is reinforced through the insignificant relationship between CBMs and the utilization of data from Overheid and the CBS as indicated through the p-values (Table 2). Thus, hypothesis 1 is rejected.

Hypothesis 2

In order to determine whether *the positive impact of open government data on the development of circular business models is reinforced through the improved decision-making triggered by higher utilization of open government data,* I created two interaction terms between OGD utilization and the quality of decision-making to conduct a regression analysis with a moderating variable. I then correlated the interaction terms with the dependent variables. Both interactions terms did not significantly correlate with the degree of circularity (Likert-scale: decision-making*overheid: p-value: 0.66; decision-making*cbs: p-value: 0.53; Range question: decision-making* overheid: p-value: 0.68; decision-making*cbs: p-value0.56). Despite this, I again proceeded with the regression analysis. The adjusted R^2 value of 0.09 for both models reveals the rather low explanatory power of the model, as only 9% of variation can be explained by it. Again all F-values are also insignificant, indicating that the independent variables cannot predict the dependent variable. Despite this, there was a significant positive relationship between the utilization of the CBS which improves decision-making and thereby positively influences the degree of circularity in the business model when measured through Likert-scale questions (Table 2). Thus, we can partially accept hypothesis 2, claiming that the quality of decision-making is positively influenced by the utilization of data from the CBS

which in turn positively influences the degree of circularity in the business model. This is however, not the case for the utilization of data from Overheid.

TABLE 2

Summary of regression outcomes

	Based on Likert-scale		**Based on range question**	
Hypothesis	**1**	**2**	**1**	**2**
n	30	30	30	30
F	0.01 *(0.99)*	1.64 *(0.19)*	0.67 *(0.52)*	1.64 *(0.47)*
Adjusted R^2	-0.07	0.09	-0.02	0.09
	Circularity	**Circularity**	**Circularity**	**Circularity**
Overheid	0.00 *(0.99)*	0.25 *(0.88)*	2.77 *(0.72)*	-42.86 *(0.53)*
CBS	-0.02 *(0.89)*	-1.88 *(0.05)**	-6.42 *(0.26)*	-14.93 *(0.69)*
Quality of decision-making		-0.05 *(0.51)*		-5.44 *(0.87)*
Decision-making*Overheid		-0.02 *(0.97)*		13.84 *(0.46)*
Decision-making*CBS		0.48 *(0.05)**		1.99 *(0.84)*
Constant	3.03 *(0.00)*	4.79 *(0.13)*		78.10 *(0.55)*

Coefficients (p-values)

Testing for the Ordinal Least Squares Assumptions

To determine whether a regression was the appropriate statistical test for the collected data, it is important to test for the regression assumptions. The same procedure was followed for both hypotheses and for both measures of the dependent variable. First, I checked for linearity creating fitted residuals plots. Neither one of the plots shows clear patterns as the observations are diverging from the plotted residuals lines (Appendix G). Thus, the linearity assumption

seems to be violated. In order to determine whether this non-linearity stems from multicollinearity between the variables, I conducted a variance inflation factor (vif) test for both hypotheses. For hypothesis 1 the vif value for both measures and both OGD variables; cbs and overheid is 1.15 which is below the commonly used threshold of 10, which means that no multicollinearity is present (UCLA, n.d.). In case of hypothesis 2, the vif values are all exceeding the threshold of 10 indicating that there is multicollinearity in the model. This however, is not of concern as the multicollinearity can be explained through the inclusion of the interactions terms and the separate variables in the model. Lastly, I conducted a Breusch Pagan / Cook Weisberg test to test for heteroskedasticity. For both hypotheses the probability of chi^2 is above the threshold of 0.05, which means that there is no problem with heteroskedasticity in the model (h1: Likert-scale: prob>chi^2: 0.49; range questions: prob>chi^2: 0.77; h2: Likert-scale: prob>chi^2: 0.94; range questions: prob>chi^2: 0.98).

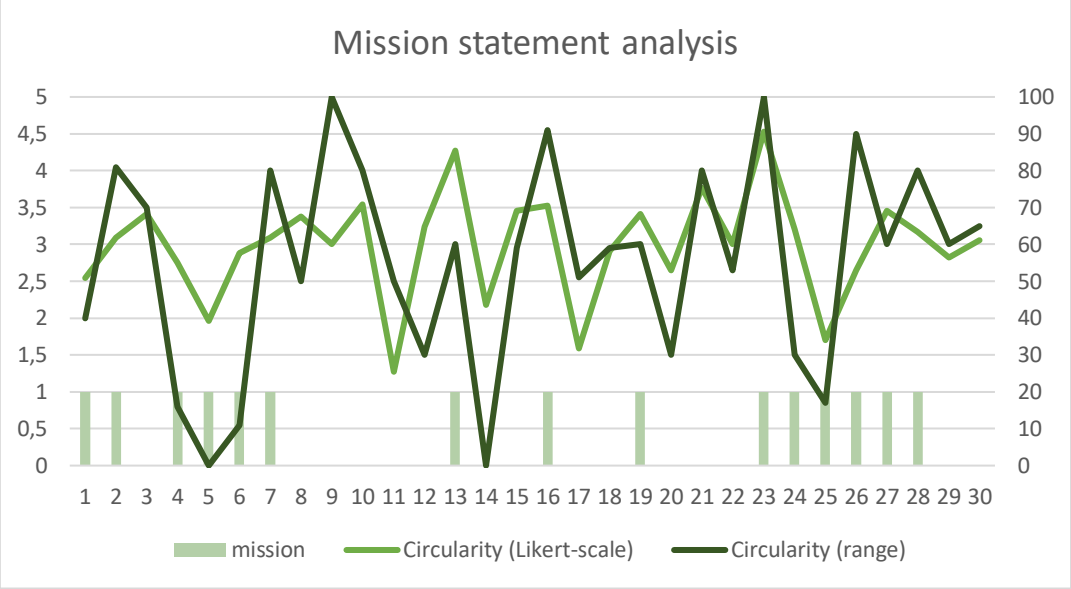
Additional Analysis

Mission Statement Analysis

Looking at the mission statement to confirm the results of the range and the Liker-scale questions, it becomes obvious that most companies, claiming to be sustainable or circular in their mission statement also pursue this through their actions (Figure 5). I created this comparison by assigning a 1 to those companies whose mission statement contains one of the previously identified keywords and a 0 to those who do not (Appendix H). Figure 5 also reveals that companies might be pursuing a CBM without stating it explicitly in their mission statement (observations 8,9, and 21). Thus, the graph representing the mission statement analysis, confirms the results obtained in the statistical analysis.

FIGURE 5

Mission statement analysis



Single Imputation with Means

Furthermore, I conducted a single imputation analysis with means to account for those incomplete observations that completed at least 50% of the questionnaire. Doing so, provides further insights into whether the results of the statistical analysis would have differed significantly if the respondents would have completed the questionnaire. I replaced the missing values in each of these incomplete observations with the means of their corresponding offering and conducted the same analysis as above with a sample size of 35. Conducting a regression for hypothesis 1 indicates no significant changes. The adjusted R^2 remains low at – 0.05 and 0.03, meaning that the model still does not explain much of the variation in the model. Similarly the, F- and p-values remained insignificant (Table 2). Therefore, hypothesis 1 remains rejected. For hypothesis 2 the adjusted R^2 remains low at 0.1 and -0.02 for the Likert-scale and range question respectively. Similarly to the main analysis, when analysing the Likert-scale question,

there remains a significant relationship between the utilization of the CBS, decision-making and the degree of circularity. Thus, hypothesis 2 is partially supported as the utilization of the CBS improves the quality of decision-making which in turn is positively related to CBMs. Again, Overheid does not seem to support increases in the quality of decision-making and does not significantly influence the degree of circularity. Thus, hypothesis 2 for Overheid remains rejected.

TABLE 2

Summary of regression outcomes single imputation analysis

	Based on Likert-scale		**Based on range question**	
Hypothesis	**1**	**2**	**1**	**2**
n	35	35	35	35
F	0.13 *(0.88)*	1.77 *(0.15)*	0.54 *(0.59)*	0.86 *(0.52)*
Adjusted R^2	-0.05	0.10	-0.03	-0.02
	Circularity	**Circularity**	**Circularity**	**Circularity**
Overheid	0.01 *(0.96)*	0.22 *(0.88)*	1.68 *(0.823)*	-17.64 *(0.79)*
CBS	-0.06 *(0.65)*	-1.81 *(0.05)**	-5.85 *(0.31)*	-16.43 *(0.67)*
Quality of decision-making		-0.46 *(0.54)*		3.77 *(0.91)*
Decision-making*Overheid		-0.02 *(0.96)*		6.52 *(0.72)*
Decision-making*CBS		0.45 *(0.05)**		2.57 *(0.79)*
Constant	3.14 *(0.00)*	4.67 *(0.11)*	63.53 *(0.00)*	41.09 *(0.75)*

DISCUSSION

Discussion of Results

This research focussed on questioning whether the expanding datasphere provided by OGD can positively influence the development of CBMs. If OGD could provide the missing insights into customer behaviour and system performance that count to the most important insights needed by circular businesses according to Luoma et al. (2021), the development of a circular economy could be accelerated by the government itself. However, as the previous sections revealed there is currently no evidence that supports the positive influence of OGD on the development of CBMs. In fact, it has been shown that the overall utilization of the main OGD platforms in the Netherlands is rather low overall. The only evidence for a positive relationship that was found was in regard to improved decision-making through the utilization of the CBS which in turn positively influences the development of CBMs. However, as the coefficient indicating this positive relationship decreased when the sample size was increased through the single imputation method, it is important to further investigate this relationship with an even larger sample size.

Conclusion

Even though this research was not able to answer its guiding research question: *To what extent does the utilization of open government data stimulate the development of circular business models?*, it still provided some valuable insights into the state of development regarding circularity in the Netherlands. CBMs seem to emerge despite the lack of needed insight from the public hemisphere, providing a hopeful lookout into the future as companies seem to proactively seek out information that helps them in creating a more circular business model. Now it is up to the Dutch government to determine ways in which they can support and enhance this proactivity to reach its goal of becoming fully circular by 2050.

Limitations

The major limitations of this research are linked to the sampling procedures. First, through the snowball methods used for the sampling, it was impossible to determine the non-response rate for the questionnaire. This makes it impossible to claim that the collected responses do not differ from the overall population, as I cannot make claims about those who did not answer the survey. This notion is reinforced through the overall small sample size which increases the difficulty of making general claims. The issue of the small sample size is also visible in the rather low power of 0.10 of the research, which means that the effect would only be discovered 10% of the times if the research would be repeated indefinitely. This could have been increased through a larger sample size, established through a method other than the EVP. Thus, a repeated study with a larger sample size might yield different results.

Another issue regarding the sample is the heterogeneous nature of it. Having respondents from varying industries in such a small sample does not allow to make general claims about any industry. Furthermore, there might also be industries for which OGD is more valuable than for others, meaning that it is essential to differentiate between those.

Another potential limitation is that I limited this research to two OGD platforms only, namely Overheid and the CBS. This was because the former was mentioned by the Dutch government in one of its OGD action plans, and because both provide insights into customer behaviour and system performance which are necessary insights for circular businesses according to Luoma et al. (2021). As a results I limited my insights to those platforms only, excluding potential other sources of OGD which firms might use.

Lastly, the central tendency bias which is inherent to Likert-scale questions might have also been in effect in this research as indicated by the means which are close to the central values

of the variables (Table 3). This bias might have distorted results as the means were used for analysis and thus, inferences could have been made on biased results.

Implications and Future Research

Despite the insignificant results, this research still yields valuable insights and implications for practice. First and foremost it is important to note that the results of this research represent the status quo in the Netherlands, meaning the current utilization of OGD by companies. This does not mean that the utilization will look similarly in the future. Further proceeding with its National Action Plan, the Dutch government can potentially increase its provision of data and the usefulness thereof in the future, potentially leading to increased use by companies. Additionally, the Dutch government and researchers should investigate how the data published by the government can be made more attractive to organizations and to CBMs in particular. Engaging in closer stakeholder cooperation with business such as listening to their data requests as well as utilizing their insights and perhaps even publishing them, could enable the Dutch government to enhance the impact of its OGD policies and simultaneously aid in the development of a circular country by 2050. In doing so, the data processing capability of CBMs could also be determined, allowing the publishers of OGD to make the data easier to analyse and use. This close cooperation is required to make the systemic change required, as mentioned by several authors, to make the transition to a circular economy (e.g. Gupta et al. 2019). Thus, qualitative research is needed to determine what OGD published by the Dutch government is currently lacking and how it could be improved.

Furthermore, it is also essential to determine which industries in particular benefit from the provision of OGD to provide valuable insights for those. These industries might be sectors which operate on the crossroads of the public and private sphere such as mobility or agricultural

businesses who are particularly dependent on information and intervention from the government. Thus, researching a more homogeneous sample might yield valuable insights.

Next to determining how OGD can be utilized effectively to foster the development of CBMs and by whom, future research should also focus on finding other sources for customer behaviour and system performance insights that are valuable for circular businesses to facilitate the development of such. As CBMs seem to be emerging despite missing data from the public sector, it is crucial to determine what sources founders and managers use to establish such business models, to further support them in their pursuit of reducing their environmental impact. Thus, future research should fill the gap of insights into customer behaviour and system performance that is currently one of the main obstacles when it comes to developing a CBM. As this research showed that OGD is not the answer yet, other sources need to be found and improvements in the information that is provided through OGD need to be made, so that the Netherlands can achieve their ambitious circularity goals.

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APPENDIX

Appendix A – OGD evaluation The Netherlands

Source	Rank	Year	Scale
OECD open government data	13	2019	Worldwide
European Data Portal	3	2018	EU28
Open Data Barometer	6	2015	Worldwide
Global Open Data Index	20	2016	Worldwide

Appendix B – Categories on Overheid

Board	Culture and Recreation	Economy	Finance	Housing
International	Space and Infrastructure	Work	Care and Health	Agriculture
Migration and Integration	Nature and Neighbourhood	Education and Science	Public Order and Safety	Law
Social Security	Traffic			

(Overheid, 2021a)

Appendix C – Circularity evaluation The Netherlands

Source	Rank	Year	Scale
Giannakitsidou, Giannikos, Chondrou	Top 5 in various categories	2020	26 European countries
Fura, Stec, Mis	2	2020	Europe
Politico	12	2018	Europe

Appendix D– Questionnaire

WELCOME

Dear participant,

thank you for agreeing to participate in this 3-5 minutes long survey. By taking part, you provide valuable insights into your business model and the utilization of open government data within your company. Please be assured that all information you are providing is and will remain anonymous and is used for research purposes only.
Please answer all questions honestly, there are no right or wrong answers.

Thank you very much for participating.

Paulina Thomas

DEMOGRAPHICS

1. When was your company founded? [open question]
2. What industry are you in? [open question]
3. How would you summarize the rationale or purpose of your organization, i.e., its mission? [open question]
4. Are your providing a service, a product, or both? [multiple choice question] [answer determines whether the respondent receives, circularity questions about products or services, or both]
    a. Product
    b. Service
    c. Both

CIRCULARITY

Product firms

Please indicate to what extent you agree to the following statements: [Likert-scale questions: completely disagree, disagree, neither agree nor disagree, agree, completely agree]

1. We are currently using 100% raw materials for our products
2. We are currently using 100% recycled materials for our products
3. We are currently using 100% recovered materials for our products
4. We are remanufacturing products from materials that were used in other products before.
5. We are actively encouraging our customers to recycle our products at the end of their useful life
6. We are actively encouraging our customers to reuse our products (i.e. buying second hand, renting, or sharing the products)
7. We are recovering the materials of our products
8. Our products can be remanufactured (i.e. new products can be created from (parts of) the product)
9. Our products are easy to repair (e.g., modular products)
10. Our products can be repurposed

11. Our products can be refurbished
12. Our company is continuously trying to reduce the resources we use
13. External stakeholders are included in our mission
14. Stakeholders contributed to the formulation of the mission
15. We are currently pursuing a long-term strategy
16. Contracts with suppliers are usually three or more years

A circular business is determined to minimize the resources used by organizations and individuals and therefore tries to help them to create less waste. Out of 100%, with 100% being fully circular, how circular would you say your business is? [0 – 100 scale]

Service firms

1. Are you providing any of the following services? [multiple choice question, several answers possible]
    a. Repair service (1)
    b. Recycling services (2)
    c. Rental services (3)
    d. Refurbishing service (4)
    e. Advisory service (5)
    f. Sharing or renting platform (6)
    g. None of the above
        i. [text entry]
2. Are you connecting customers and suppliers of the following services? [multiple choice question]
    a. Repair service (1)
    b. Recycling service (2)
    c. Rental service (3)
    d. None of the above
        i. [text entry]

Please indicate to what extent you agree to the following statements: [Likert-scale questions: completely disagree, disagree, neither agree nor disagree, agree, completely agree]

1. Our company is continuously trying to reduce the resources we use
2. We are currently using 100% raw materials for our operations
3. We are helping our customers to repurpose items
4. We are helping our customers to reduce their waste
5. We are helping our customers to recover waste
6. We are currently pursuing a long-term strategy
7. Contracts with partners are usually three or more years
8. External stakeholders are included in our mission
9. Stakeholders contributed to the formulation of the mission

A circular business is a business that aims to operate successfully while preventing waste where possible in order to restore or protect the natural environment.Out of 100%, with 100% being fully circular, how circular would you say your business is? [0 – 100 scale]

OGD USAGE

Please indicate to what extent you agree to the following statements: [Likert-scale questions: completely disagree, disagree, neither agree nor disagree, agree, completely agree]

1. Are you using www.data.overheid.nl to gather data for your operations?
    a. Picture of the overheid logo to stimulate memory
2. The data from overheid.nl is essential for our operations
3. We use data from overheid.nl daily
4. We use data from overheid.nl weekly
5. We use data from overheid.nl monthly
6. We analyse data from overheid.nl
7. We base actions on data from overheid.nl

Please indicate to what extent you agree to the following statements: [Likert-scale questions: completely disagree, disagree, neither agree nor disagree, agree, completely agree]

1. Are you using data from the Centraal Buerau voor de Statistiek (CBS) to gather data for your operations?
    a. Picture of the CBS logo to stimulate memory
2. The data from the CBS is essential for our operations
3. We use data from the CBS daily
4. We use data from the CBS weekly
5. We use data from the CBS monthly
6. We analyse data from the CBS
7. We base actions on data from the CBS

QUALITY OF DECISION-MAKING

Please indicate the extent to which the following statements are true in regard to making important (not day-to-day) decisions within your company. [Likert-scale questions: completely disagree, disagree, neither agree nor disagree, agree, completely agree]

1. When making a decision we search for three or more choices.
2. When making a decisions we take into account all values and all goals desired.
3. When making a decision we weight the pros and cons of consequences.
4. When making a decision we find more information about the pros and cons, when needed.
5. When making a decision we think about new information and consider the opinion of experts even if that is against our first choice.
6. When making a decision, we review everything carefully before making a final choice
7. When making a decision we make detailed plans and backup plans.

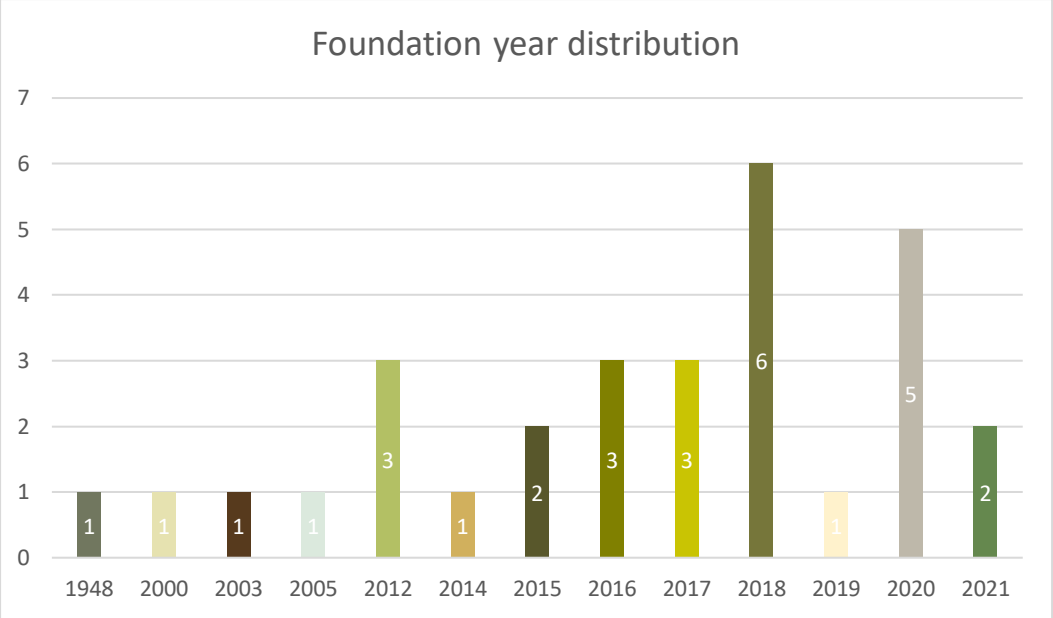
THANK YOU MESSAGE

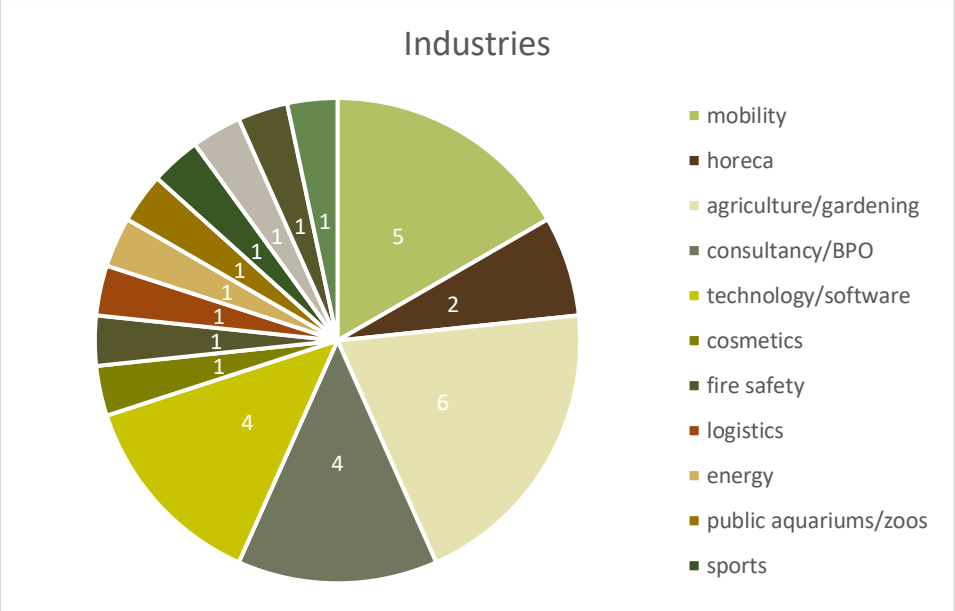
Thank you for participating in this survey. Your data will help me with my Master Thesis researching the relationship between open government data utilization and circular business models. If you would like to receive the results of this research, or have some follow up questions, please contact me under: p.thomas.3@student.rug.nl.

Appendix E – Cronbach's alpha

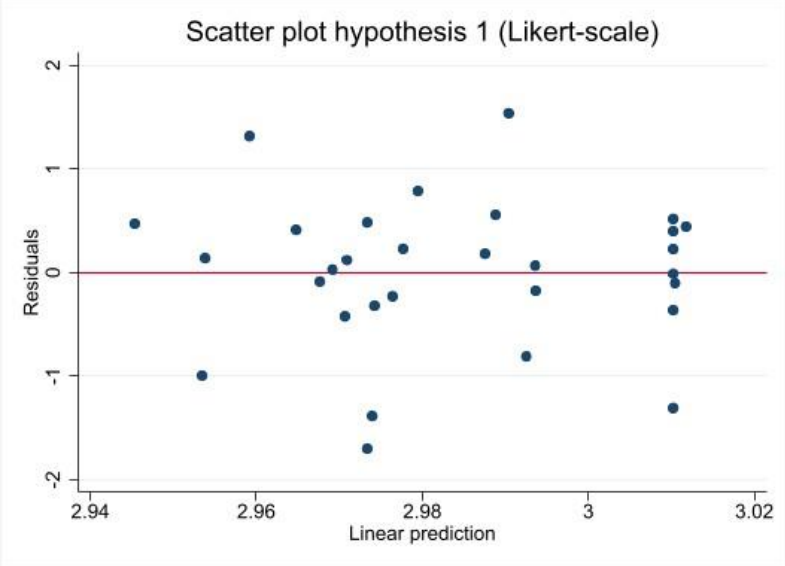
Construct	Cronbach's alpha	N
Circularity (product companies)	0.90	17
Circularity (service companies)	0.82	9
Circularity (companies offering both; service & product)	0.87	24
Overheid utilization	0.93	7
CBS utilization	0.91	7
Quality of decision-making	0.78	7

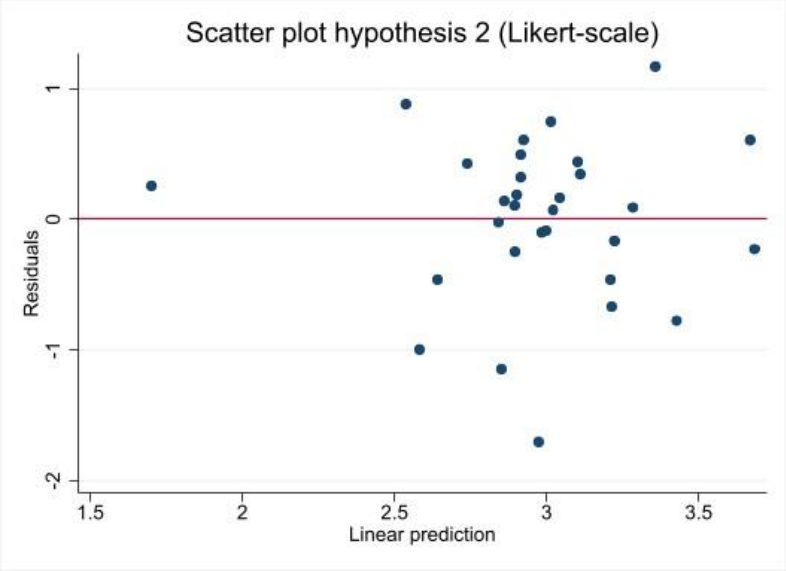
Appendix F – Descriptive statistics

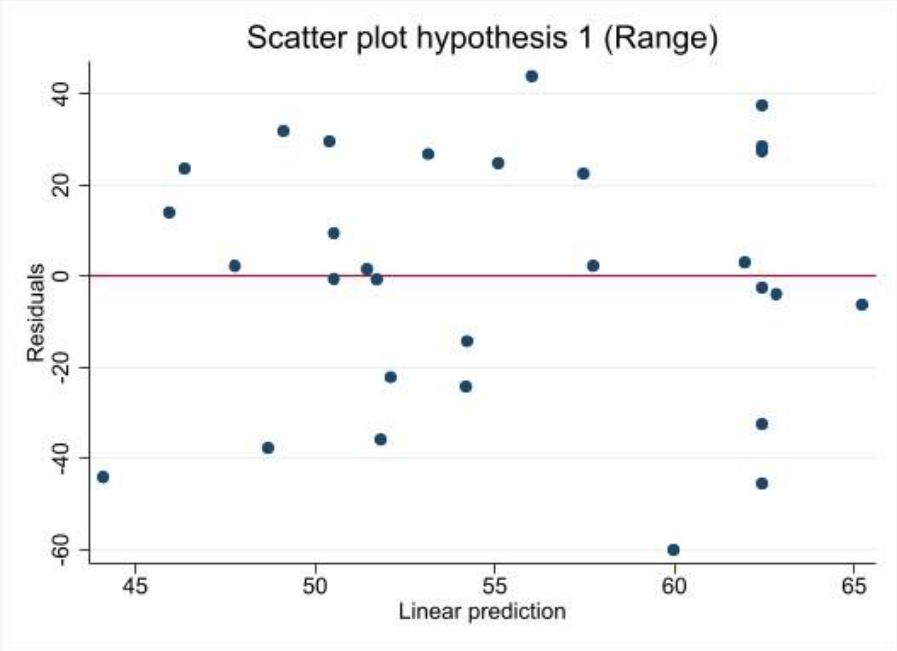


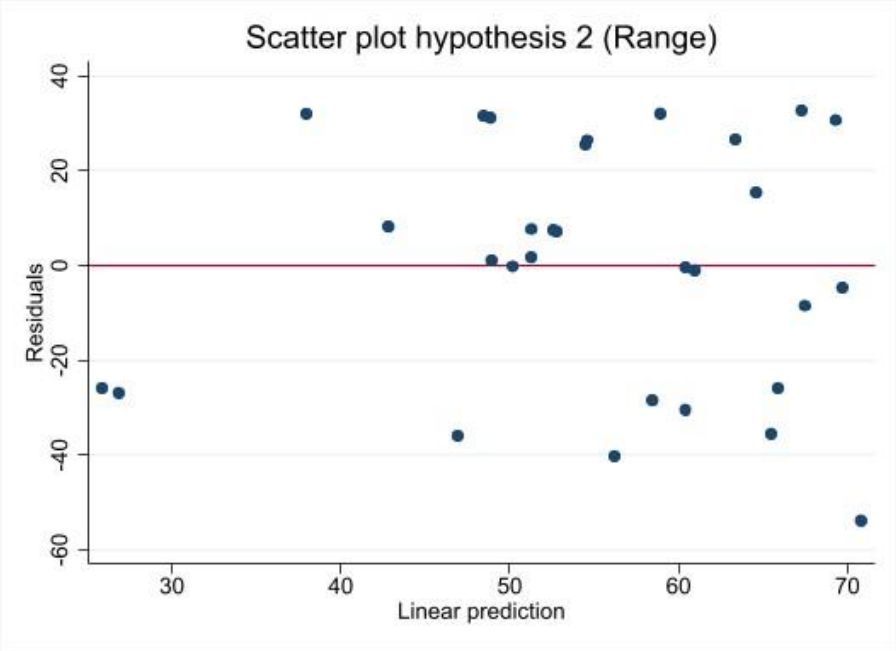


Appendix G – Fitted residuals plots




Scatter plot hypothesis 2 (Likert-scale)
Residuals
1
0
-1
-2
1.5
2
2.5
3
3.5
Linear prediction


Scatter plot hypothesis 1 (Range)
Residuals
40
20
0
-20
-40
-60
45
50
55
60
65
Linear prediction



Appendix H – Mission statement analysis

The following companies were used as examples due to their well-known circular business

Model. As circular business models are not a Dutch phenomenon, also non-Dutch companies were used as examples.

Mission statement	**Keywords**
Every year more than 250 million kilos of coffee grounds are produced in the Netherlands. Much of this ends up in the waste incineration. That's a shame! Coffee Based ensures that this material is utilized better by making biobased products from this waste (Coffee Based, 2021).	Waste, bio
BE On a mission Make a real impact. That is our mission. That is why we make climate-positive products from plants, such as sugar cane. This means that our products absorb more CO2 than they emit (BE O Lifestyle, 2021) .	Impact, climate positive, CO2
Create the world's smartest energy storage solutions that benefit people, business, and the planet (Clarios, 2021).	Triple bottom line
We dream of a better tomorrow, so we make shoes with brighter futures. We are on a mission to empower our community to step up. We are fueled by kinship, optimism, and hope to build the future we	Future, empower, community

want to see. Join us and step out into the world supported by Thousand Fell. (Thousandfell, 2021)	
Pioneering the end of waste – Conserving water and air via upcycling (Looptworks, 2021)	Conserving, upcycling
Imagine a world where you could take waste carbon emissions and convert them to new products, cleaning our air and giving carbon a second chance. That world exists today with LanzaTech. (Lanzatech, 2021)	Waste, carbon emissions, convert, second chance, cleaning
we have big plans to make the world a cleaner, greener, more colorful place. we invite everyone to join us as we pioneer a future where doing business is doing good for all. (method, 2021)	Cleaner, greener, future , doing good
divert 100 million tonnes of waste from landfill by 2025 (globechain, 2021)	waste
Each brick, board, piece of wood or glass in a building has a value. Today, these materials are often not reused after demolition or refurbishments, instead they are wasted. BAMB has provided the tools to enabling a circular building industry (Bamb, 2021).	Waste, reuse, circular
At Philips, we are striving to make the world healthier and more sustainable through innovation, with the goal of improving the lives of 3 billion people a year by 2030. (Philips, 2021)	Sustainable, improving lives
As a Circos member, you make a difference and reduce your family's carbon footprint by up to 80% for the items you rent instead of buy (Circos, 2021).	Carbon footprint, reduce, rent