The (un)certainty of plastic recycling innovations

An analysis of the influence of policy uncertainty on innovations in the plastic recycling industry

Master Thesis, 7 August 2017 Leiden University Faculty of Public administration

Author:	Jeroen Cevaal (s1751344)
Supervisor:	Dr. M.C. Berg
Second reader:	Dr. P.W. van Wijck

Abstract

The current linear consumption patterns are not sustainable, especially because the use of plastic has increased twenty-fold over the last fifty and is expected to double again in twenty years. To reach a circular model for plastic, technological innovation is required to facilitate the transition towards circularity. Considering that policy and regulations are the foundation of the (plastic) recycling industry, this study investigates how uncertainty regarding policy affects innovations in plastic recycling and if policy uncertainty is limiting the transition to a circular economy. In this study, semi-structured interviews have been conducted to gain insight in the perception and experience of public policy makers and plastic recycling companies. This study shows that policy uncertainty negatively affects innovation in a variety of ways. At the same time, the development of policy is rather incremental due to the path dependency of policy and regulation can be ambiguous.

Contents

1. Introduction

Plastic has become a commodity product in the modern economy and the use of it has increased twenty-fold over the last fifty years, and it is expected to double again in the next 20 years (Ellen MacArthur Foundation & McKinsey, 2016; p. 15). Our current economic model is based on a 'take-make-consume-throw away' pattern. In this model, products are created for single use which is not sustainable considering the growing demand for (plastic) products (Plastics Europe, 2016a) and steady rise of global citizens. The necessary change requires a shift from the current linear consumption pattern towards a circular consumption pattern. In a circular economy, the value of products and materials is maintained, waste and the use of resources are minimized and after a product has reached its end of life, it is used again to create value. This change is considered necessary because of environmental and economic reasons. From an environmental perspective, the use of plastic results in negative externalities related to the degradation of natural systems, greenhouse gas emission and health and environmental impacts. In 2015, 8 million tonnes of plastic leaked into the ocean – the equivalent of the content of one garbage truck dumping its load every minute – and without change, in 2050 the ratio of plastics to fish will be >1:1 whereas it is currently 1:5 (Ellen MacArthur Foundation & McKinsey, 2016; p.28). From an economical perspective, a circular model captures the value of end-of-life products. Currently, only 5% of the material value of plastic packaging is captured (4 – 6 billion USD) which leaves a potential material value between 80 and 120 billion USD (McKinsey, 2016) for the market to be seized. To capture all potential value is not deemed realistic, however, it does show the immense economic potential of the circular economy. Another economic benefit is that businesses are less dependent on the price volatility of virgin feedstock because the market of secondary raw materials provides a quality substitute for virgin plastic (European Commission, 2016a). Additionally, a circular economy results in a reduction of negative externalities, such as air pollution and climate change as a consequence of greenhouse gas emissions, by preserving and re-using resources it allows for costs savings in the industry and unlocks new business opportunities.

In order to achieve a systematic shift and to move beyond small-scale and incremental improvements, a global collaborative initiative is required. Moving towards circularity for plastic requires collaboration between industries, non-governmental organisations (NGO's) and (local) governments (Ellen MacArthur Foundation & McKinsey, 2016; p. 39). Collaborating is necessary considering that actors play a different, although crucial, role in the plastic recycling process. To overcome fragmentation, lack of alignment in the value chain and the lack of (global) standards, this collaboration is required. The packaging industry is responsible for the products and materials that enter the market, (local) governments are responsible for waste collection and the formulation of legislation, whereas recycling

businesses are executing the collection, sorting and reprocessing of waste, thereby contributing in their own way. NGO's protect broader environmental implications as well as social considerations. The lack of alignment relates to the product design stage and after-use stage, resulting in product designs that are not suitable for recycling. For example, global standards, such as the mathematical way recycling is calculated, are non-existing. A collaboration between industries, NGO's and (local) governments is required as a holistic approach is desired. To enable the transition, policy makers are important to realign incentives, facilitating secondary markets, defining standards and stimulating innovation (Ellen MacArthur & McKinsey, 2016; p. 39). The European Commission (2016a) has adopted a holistic approach to reach the goal of plastic circularity and emphasizes the need to innovate throughout the entire value chain. The Ellen MacArthur Foundation (2016) and Plastics Europe (2016a) advocate to move beyond the Commission's proposal, namely that cross- value chain action is required to seize the opportunities of a circular economy for plastic. Bringing together different actors across the global value chain in a dialogue mechanism can help to connect the development of new packaging materials to the required after-use systems and infrastructure. Technological innovations could be capable of achieving high recycling rates for countries but that requires coordination and collaboration. From a political perspective, governments use legislation as an instrument that can positively affect the transition to a circular economy. The Circular Economy Package, the European Commission's action plan for circular economy, consists of several directives with the purpose of reducing waste and to establish recycling. On a European level, a directive is a legislative act that sets a goal that all EU countries must achieve. However, it is up to the member states to devise their own laws on how to reach these goals (European Union, 2017). In contrast with a directive, a regulation is a binding legislative act and it must be applied in its entirety across the European Union (European Union, 2017). The implementation of national laws allows for flexibility in the measures taken to achieve the goal set in the directive. This flexibility in directives is beneficial because the directive sets an EU wide minimum standard but at the same time allows governments to apply more stringent regulation and reach higher standards. Legislation, however, should not be focused on recycling, as that represents just a part of the value chain of plastic, but on the entire value chain in order to achieve maximum results. Because the problems of collection, sorting and reprocessing are often caused early in the value chain of plastic, legislation should address the entire value chain using a holistic approach.

The lack of coordination has resulted in proliferation of materials, formats and labelling schemes (Ellen MacArthur Foundation & McKinsey, 2016; p.50). In the design phase, decisions regarding the use of (a combination of) different materials and the amount of layers affect the functionalities of the product. However, using of multi layered plastic packaging is causes problems for sorting and reprocessing. Regulation could provide a solution to this problem by providing design guidelines on which plastics to

use for a particular functionality. In addition, prescribing a plastic type that has the desired functionalities which can be used in a wide variety of products (i.e. standard setting) could help the transition towards circularity.

The European Union is addressing this problem with the adoption of the Circular Economy Action Package in 2015. The actions contribute to closing the loop by covering the whole cycle: from production and consumption to waste and the market for secondary raw materials (European Commission, 2016a). The adoption of legislative proposals on waste include a common EU target for recycling 65% of municipal waste and 75% packaging waste by 2030. A ban on landfill for separately collected waste and a binding landfill target to reduce landfilling of municipal waste to a maximum of 10% by 2030 (European Commission, 2016a).

However, as the French President Hollande said, the biggest problem of the European Union is its slow decision-making process: "in the end Europe always succeeds in finding a solution, but we have to pay a high price for the lost time" (Business Insider, 2016). A slow decision-making process (or lack of decisions) results in a situation in which companies do not know what to anticipate on, then there is uncertainty about the government's future path, called policy uncertainty. Policy uncertainty does not only limit itself to a slow decision-making process, but ambiguous- and vague policy or policies that go back and forth also contribute to the uncertainty related to policy. Policy uncertainty has negative effects on investments which are required to innovate and to achieve circularity (Bernanke, 1983; Higgs, 1997; Barradale, 2010). The level of governmental support for waste recycling technologies and the changing policy regarding the availability of different subsidies for developing technologies are causing uncertainty for businesses (Meijer, 2008). Also the way in which businesses will receive support from the government is part of the uncertainty. In the United Kingdom, investments have dropped due to the economic and political uncertainty caused by the 'Brexit' referendum (Recycling Waste World, 2015). Therefore, to reach circular economy for plastic, policies should push for circularity and the uncertainty regarding future policy should be reduced.

In order to stimulate plastic recycling innovations through reducing the policy uncertainty it is necessary to understand the relationship between innovations in plastic recycling and policy uncertainty. However, to come up with concrete recommendations that are specifically for the plastic recycling industry, it is important to determine if policy uncertainty is a limiting factor for reaching circularity for plastics. This results in the following central research question:

> *How does policy uncertainty affects innovations in plastic recycling and is policy uncertainty a limiting factor for achieving circular economy for plastic?*

1.1 Relevance

The concept of (policy) uncertainty and its effects have been researched extensively. Political uncertainty has negative effects on securing investments (Higgs, 1997; Barradale, 2010) as well as the quantity, quality and originality of innovations (Bhattacharya, 2013). In situations characterized by high policy uncertainty, companies tend to participate in the policy-making process to exert influence over the outcome (Engau & Hoffmann, 2009). This costs a considerable amount of resources and shifts their focus away from innovating as well as their core business.

The options for future policy are limited because of decisions made in the past that influence the possible policy options. This so called path dependency eliminates policy uncertainty to a certain extent, however, not entirely. Uncertainty remains over the actual future path that the government will take within the pre-determined set of available options. As policy options are eliminated because of path dependency, the uncertainty decreases. The restriction with regards to the available policy options for policy makers (Kay, 2005) pose a challenge for policy makers as policy change can only occur within the predetermined set of options. It is likely that existing practices continue and change is incremental because in order to adapt to a new approach, new information is required. Avoiding the acquisition of new information results in policy makers making sub-optimal decisions by following the current regulatory path instead of a new path that results in better outcomes (Kirk et al., 2007). From a political perspective, technological innovations require to be regulated as they can cause concerns for health and safety (OECD, 2015a), but in order to provide an environment in which companies can innovate, innovation policy is in place to help businesses improve their capacity to innovate (Paraskevopoulou, 2012). Rothwell (1980) argues that regulation is not a stimulating factor for innovations because of the costs to be in compliance with regulation, however, as the OECD (2015b) frames it, a high quality regulatory framework should facilitate market entry and growth for innovative businesses. For environmental regulation, as opposed to the traditional view that regulation has a negative impact on performance, Porter (1991) argues that when designed with focus on outcome it will encourage change and increase resource efficiency. A negative aspect of environmental regulation is that it is a market entry barrier for new entrants due to compliance costs (Ramanathan et al., 2010). Although the OECD (2015b) argues that regulation can facilitate market entry, this is only the case when there is a high quality framework in place. However, specifically for environmental regulation, following the reasoning of Ramanathan et al. (2010) there is no high quality framework resulting in barriers to enter the market. The dilemma is to formulate policies in such a way that it provides certainty for businesses with regards to innovation and that the costs of compliance with regulation is low to the extent that it poses no market entry barrier for new (innovative) firms.

This research aims to provide insight in the relationship between policy uncertainty and innovations in plastic recycling through a comparative case study. Understanding the causality, both government and the industry can benefit. Policy makers are provided with best practices on how to formulate recycling regulation in such a way it yields maximum benefits whereas society benefits from increased recycling rates and a reduction of negative externalities. Recycling plastic waste is an enormous challenge, it touches not only upon multiple United Nations Global Development Goals, it also provides enormous economic and environmental benefits (Ellen McArthur Foundation & McKinsey, 2016).

2. Theoretical framework

The section elaborates upon the three main concepts used within this study, namely policy uncertainty and how to deal with this type of uncertainty, path dependency and regulatory burden. Next, the concepts economic conditions as well as entrepreneurial culture are elaborated on. Following is an explanation of the process of plastic recycling, including the current situation in Europe and the challenges regarding plastic recycling.

2.1 Policy uncertainty

Policy uncertainty arises when the government's future policy path consists of multiple options, but there is no knowledge available to determine which option is (most) likely to be chosen. In situations where (economic) investments are based on or influenced by government decisions in the future, the investment risk increases. "Investments are sensitive to risks in various forms, including uncertainty over future tax and regulatory policy" (Pindyck, 1991; p. 1141). Higgs argues that uncertainty has negative effects on investments. Schumpeter (1939, in Higgs 1997; p.569) observed "how unrealistic any theory of investment opportunity is which leaves the political factor out of account."

Policy uncertainty is a known deterrent in securing investment (Barradale, 2010; p. 7698) and, as Bhattacharya (2013; p. 27) shows, has adverse effects on the quality, quantity and originality of innovations. Moreover, adverse economic consequences of policy uncertainty hamper original and high quality innovations (Bhattacharya, 2013; p. 27). However, inevitably, innovations deal with uncertainty, especially when it concerns new technologies that require regulation for health and safety issues.

Particularly environmental regulation is characterized by a high level of policy uncertainty. Engau and Hoffmann (2009; p. 767) argue that this is because "it is typically based on very long-term considerations, with science playing an important role in agenda setting, policy making and evaluation." A case study conducted by Engau and Hoffman (2009) shows that higher perceived uncertainty regarding a specific regulation that affects a corporate business, the greater the extent to which the corporate businesses participate in the policy making process. This process, described as rent-seeking (Krueger, 1974), provides an opportunity for businesses to be involved with policy makers in making reliable planning that could be used for making investments. Krueger (1974) argues that rent-seeking is competitive and requires resources to compete for the rent. This is supported by Engau and Hoffman (2009) who show that contributing to the policy making process requires additional resources and having alternative strategic options requires to commit. Participating in the policy process, decreases the company's efforts to produce innovations with a high quality, quantity and originality as a result of misallocation of resources in the economy.

The impact uncertainty has on growth and investment has been investigated by various researchers in the past (Bernanke, 1983; Carruth et al., 2000; Kang et al., 2014; Baker et al., 2016), who concluded that a high level of uncertainty gives firms an incentive to delay investment. Innovations require, by definition, an investment in terms of resources or time dedication. Increasing the uncertainty a firm has to deal with, therefore, results in a decreased chance of making innovation related investments. Arentsen et al. (2000) argue that especially environmental regulation, including plastic waste recycling, is characterized by high uncertainty due to several reasons: 1) besides the interests for people, interests of plants and animals are included; 2) it involves the interests of future generations; 3) science plays an important role throughout the policy process – creating tension with the political process and 4) the policy objectives tend to be less incremental than most other policies. Following the line of Arentsen et al. (2000) the incentive for, and change of, investment is decreased.

Governmental innovation policies are aimed at improving policies that affect innovation and research and development (R&D) performance. Policy considerations may be, as Marcus describes (1981; p.446), "not the critical factor that affects innovation, although they play an important role." Other factors have been identified as influencing innovation as well, including social, cultural, economic and political factors that are interrelated and interact with each other. As public policies shape the environment in which businesses are active and affect variables influencing innovation, they should be considered as an important factor for innovation. The dilemma, however, is how to formulate policies in such a way that the costs of compliance are limited and the industry's freedom to operate and innovate remains intact. The formulation of innovation policy is difficult as the outcome of innovations are in general characterized with a high degree of uncertainty (Rothwell, 1980).

The current linear way of using resources and recycling is not sustainable, change is necessary to reach a circular economy (Ellen MacArthur Foundation & McKinsey, 2016; p. 26). Market incentives have perverse effects on plastic waste recycling and the shift towards a circular economic model. Businesses have an incentive to innovate, as it allows them to benefit from the first-mover advantage. To reach a circular economy, global collaboration among industries, governments and NGOs is required (Ellen MacArthur Foundation & McKinsey, 2016; p. 26). Governments should step in to overcome fragmentation and to reach global standards for businesses. Considering that both industry and government play a role within the value chain of plastic, policy makers should not rely solely on the (usually) incremental innovations put forward by the industry but push for more radical and disruptive innovations. Innovations inevitably have dealings and conflicts with policies that are applicable to them, making them interdependent on each other. Therefore, the policy goals are as such that innovation in waste recycling technologies is inevitable. In turn, innovations are invented around boundaries set by policies.

To illustrate, climate policies are subject to policy changes. Changing the definition of 'recycling' serves as example. Changing the definition of recycling has implications for the calculation of the amount of plastic that is recycled because the method to calculate how much waste is recycled has changed and caused uncertainty. The calculation method can be either the volume of material that is collected or the volume of material that arrives at the recycling plant, or the amount of material that is the output of the recycling plant (Let's Recycle, 2017). A second example shows clearly that investments are being sensitive to risk (Pindyck, 1991). After investing in an innovative technology to recycle PVC, a technology that has won several innovation awards, regulatory policy changed and the same technology that won innovation awards is now causing the risk of committing an economic offense because it involves the transport of hazardous waste (cross-border) and the processing in a plant which does not have the required license for this specific (hazardous) material.

2.1.1 Dealing with uncertainty

Policy makers that have to choose between a more promising but uncertain option and a less promising but more certain option are faced with the innovation dilemma (Ben-Haim et al., 2013; p. 130). The uncertainties causing the innovation dilemma are severe and unstructured and caused by unknown mechanisms, interactions or contingencies (Ben-Haim et al., 2013; p. 130). The problem of uncertainty is particularly present in the context of environmental decision-making because of the dynamic natural processes involved, the diversity of nature as well as many complex interactions between nature and human (Sigel et al., 2010; p. 502). It is very difficult to take into consideration all factors that influence the outcome of environmental decisions, or are a consequence of the outcome, because the amount of variables is too large. The human research capacity is not capable to comprehend or model the complexity of nature, which becomes clear in the case of cloud seeding (e.g. weather modification) where the effects of using certain materials on the environment are disputed. Another example is found in Australia, where the consequences for the environment due to the import of rabbits are devastating, and were not anticipated beforehand. The effects (on nature) of decisions in environmental policies don't become evident until they have been researched, which takes time, resulting in environmental policies being characterized with a higher uncertainty.

The standard approach in dealing with uncertainty is to quantify the uncertainty in terms of probabilities. However, as Sigel et al. argue (2010; p. 503), "it is important to make a distinction between uncertainty and risk. In uncertainty situations, all possible outcomes but not all probabilities of these outcomes are known. In risk situations all possible outcomes and all probabilities of these outcomes are known." This distinction should be considered when making investments when there is uncertainty. Risks are inherent to investments. Uncertainty however, should be avoided as it is unclear

what the possible outcome will be and how likely it will be. This comes on top of the risk that is involved with investment.

Policy makers, when dealing with uncertainty, focus on how uncertainty will affect the agenda-setting process and how it can be used to the advantage of the policy maker. When predicting possible future scenarios using forecasting, a surprise-free future is explored because no radical change or big surprise is expected (Enserink, 2013; p. 4). By selectively using a single scenario, policy makers aim to decrease the uncertainty they are facing, thus influencing the political agenda. In addition, Enserink (2013), shows that communicating about uncertainties and risks is difficult in a politicized environment and that in politics short-term concerns tend to get more attention than long-term problems, as politicians, usually, don't think beyond the next elections.

Summarizing, the implications policy uncertainty has on businesses can be linked to a decreased incentive to invest (Arentsen et al., 2000) and to the impact of uncertainty for businesses on growth and investment which constitutes of incentive to delay investment (Bernanke, 1983; Carruth et al., 2000; Kang et al., 2014). In addition to be a deterrent in securing investment for businesses, policy uncertainty has a negative effect on businesses that innovate because of the adverse effects on quality, quantity and originality (Bhattacharya, 2013).

2.2 The path dependency of policy

A process is considered path dependent if initial decisions in a certain direction elicit further decisions in the same direction. The future trajectory of a policy is constrained by the historical trajectory or historical decisions of that policy. Policy decisions, made over time, influence and restrict options for future decision-making (Kay, 2005). Historical decisions can be used to explain policy stability and change, as they influence the options for future decisions. Kirk et al. (2007; p. 252) explains that "when choices must be made the option most likely to be chosen is that which most closely resembles existing practice or previous choices." Path dependency is capable of providing causality in retrospect but the concept of path dependency cannot be used to explain current or future phenomena. Central to the notion of path dependency is stability: observations of change challenge the notion (Kay, 2005). The common criticism is the lack of explanatory power of path dependency (Raadschelders, 1998; Thelen, 1999; Kay, 2005). Except for the initial policy choice, the deterministic effects of path dependency influence future development in such a way that it becomes mechanical.

Although path dependency allows for policy change, it does so within a predetermined set of options. Kay (2005; p. 266) argues that although policies change, they are stable as the future path is somewhat determined. Path dependency theory highlights that "adopting a new approach requires acquisition of information on the possible approaches and investment in training and/or equipment" (Woerdman,

2004). However, acquiring new information and invest in training induces switching costs. Decision makers avoid switching costs, preventing them from making the best possible decision based on all available information. Following this line of reasoning, it is very unlikely to implement a radical new approach when policies are path dependent. Kirk et al. (2007; p. 254) conclude that "the effect of path dependency is that an existing regulatory path is more likely to be followed than a new one taken – even though the new path would deliver better results, such as more effective protection from the environment."

Path dependency constrains desired changes to current environmental and recycling regulations and influences decision making. Regulators are faced with resource constraints (i.e. incomplete information) and as a result have to make decisions based on imperfect information, resulting in sub-optimal outcomes. Although the problem of plastic waste recycling is widely acknowledged (European Commission 2017c, Ellen MacArthur Foundation & McKinsey 2016, United Nations, 2004), path dependency poses a challenge for the government in the sense that existing and undesired technologies, such as landfilling plastic waste or incineration, should be replaced through regulation and market incentives. However, incumbents change and innovate incrementally. This step-by-step improvement of existing technologies, stands opposite to radical innovation which is discontinuous and involves the displacement of dominant firms and institutions (Ashford and Hall, 2011; p. 273). Christensen describes the former as sustaining innovations and the latter as disruptive innovations (1997). The way incumbent firms respond and profit from new strict regulations has been researched by van der Poel (2000) who concludes that the dynamics new entrants bring are being overlooked. Christensen (1997) argues that unless incumbent firms have the willingness and capability to produce and compete with the new forms of technology, they are too likely to be replaced from the market. The figure below visualizes the difference between current technology and the path it will continue to take compared to new sustaining technologies. On the right side are, what Christensen (2015) describes, disruptive innovations. Interesting here is that although the costs are equal, disruptive innovation outperforms the 'old' technologies.

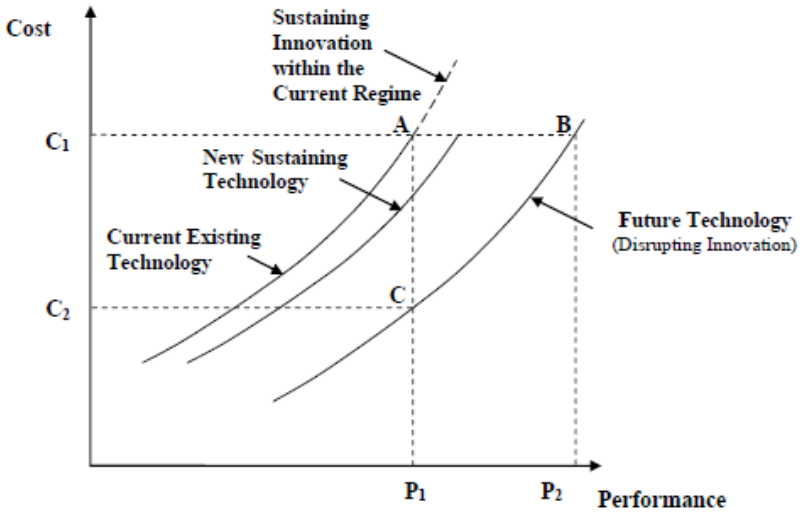

Figure 2.1: Sustaining innovation and disruptive innovations. Source: Ashford and Hall, 2011 p. 276

Following the current path, the available technologies for plastic waste are innovated incrementally. However, considering the need for change due to the unsustainability of the current linear consumption and the need to achieve circularity, policy is required to change accordingly. Incremental innovations have a more continuous character, as they occur frequently, compared to disruptive innovations which are less common. As figure 2.1 shows, disruptive innovations are desirable from a performance perspective as they heavily outperform incremental innovations but are not considerably more expensive. This does not imply incremental innovations should be considered obsolete, they are certainly beneficial, however, aiming for disruptive innovations will result in higher performance. Policy change is, according to Hay (2002, in Kay 2005, p. 566), often characterized by moments of crisis. Environmental regulation, as well as health and safety regulation, can lead to dramatic innovations. By stimulating incumbents to develop new products and technologies, but also by creating conditions that are favorable to new entrants with new products and technologies. Incumbents have a small incentive to develop new products and technologies as they benefit from the status quo. For instance when looking at the plastic packaging industry, responsible for the design of packages, there is a trade-off between the functional requirements (i.e. product protection, brand recognition, information) and recyclability. Using multiple layers of plastic for different purposes results in a package that is impossible to recycle. In this example, government regulation could impose design requirements to ensure recycling of plastic packaging waste and to stimulate incumbents to innovate. Innovative companies are faced with uncertainty regarding available subsidies, R&D tax policy and market entry barriers. For innovative companies, governmental regulation could lower barriers to enter the market and communicate clearly about available subsidies and R&D tax policy. According to Ashford and Hall (2011), regulations can be used to set tough standards that trigger innovation and upgrading of existing

technologies. However, these strict environmental regulations should be properly constructed and aimed at outcomes (Porter, 1991 in Ashford and Hall 2011; p. 277).

To change undesired technologies, new regulation and market incentives are provided to steer incumbents towards developing new technologies. However, as Ashford and Hall (2011) mention, incumbents will not set targets they cannot meet and should therefore not be allowed to participate in policy making as they will continue on the path that they have been on for a while. For policy makers, uncertainty regarding the impact of more stringent regulation on the industry is considered as one of the reasons governments refrain from implementing stringent regulations, although the benefits of imposing stringent regulations on sustainability are clear and the alternative is clearly not beneficial. Stringent regulation for recycling is favorable from a social, environmental and political perspective but unfavorable from the perspective of businesses, as they benefit from the status quo and incremental change. The challenge for government is to maintain good relationships with the industry while at the same time setting ambitious targets that are needed to reach circularity for plastics.

2.3 The influence of regulation on innovation

The development of new technologies can affect the functioning of existing markets or industries, however, as the OECD (2015a) notices, (disruptive) innovations can give rise to legitimate public policy concerns regarding safety or privacy which translates in a demand for regulation. There is no doubt that policy and regulation are necessary for the well-being of society and have an effect on innovations (Rothwell, 1980). To protect the environment and health of citizens, regulation is imposed to restrict behaviour that threatens the environment or health of citizens, or to correct for externalities caused by the market. Regulation helps to shape the climate in which industries have to operate, thus the effect of regulation is indirect (Rothwell, 1980). To understand the relationship between regulation and innovation (policy) on technological innovations, a clear distinction is required between the various types of regulation and innovation policy. The OECD distinguishes between economic, social and institutional regulations. Economic regulation intervenes directly in decisions regarding pricing, competition, market entry, or exit (OECD, 1997). It aims to avoid market failures and it uses price regulation to protect the demand or supply side. Through de-regulation, using efficiency-promoting regulation and by improving regulatory frameworks for the functioning of the market, economic regulation aims to increase economic efficiency by reducing barriers to competition and innovation (OECD, 1997). Social regulation is aimed to protect the public interest, such as health, safety and the environment. Social regulations might have economic effects that can be of secondary importance but nonetheless substantial (OECD, 1997). It involves reducing or preventing negative externalities from the environment and deals with consumer- and labour safety regulations. There is a discrepancy between the value of some public interests that citizens consider important but markets do not. Social

regulation, therefore, is essential for preserving the environment and protecting consumers and vulnerable social and economic groups (OECD, 1997). Institutional regulations consist of a framework based on liability law and include formalities through which information is collected by governments to intervene. Georghiou (2006) defines innovation policy as "any policy which seeks to help firms, singly or collectively, to improve their capacity to innovate" whereas Kuhlman (2001; p. 954) defines innovation policy as "the integral of all state initiative regarding science, education, research, technology policy and industrial modernization, overlapping also with industrial, environmental, labour and social policies." Furthermore, innovation policy can be classified as regulatory policy that includes innovation itself as objective or as policy that does not directly address innovation but has a moderating effect on them (Paraskevopoulou, 2012; p. 1059).

Rothwell (1980; p. 33) discovered that "there is little evidence to suggest that regulation stimulates innovations. " In order to be in compliance with regulation businesses have to invest time and financial resources. These costs place an unwelcome burden on innovators (Rothwell, 1980). Having a high-quality regulatory framework, according to the OECD (2015b), facilitates market entry and growth for innovative businesses as the cost of compliance are considerably lower. Administrative burden, regulatory protection of incumbents and the complexity of regulatory protection of incumbents are the main barriers related to regulation (OECD, 2015b). Porter (1991) argues that environmental regulations can positively influence performance. However, the traditional view considers the regulation to be harmful to the economic competitiveness, and although it is desirable from a social perspective it induces costs on firms that they would not have otherwise. The increase in costs results in less financial performance and decreases the competitiveness on an international level. The relationship between environmental regulation and competitiveness, according to classical economic analysis (Ashford and Hall, 2011), maintains that stringent regulation diverts resources from R&D, increases production costs and as a consequence hinders innovation. This is in line with Rothwell's (1980) findings, he showed that regulatory compliance costs require investment in time and resources which hinder innovation and therefore regulation is considered a limiting factor for innovation. In the classical economic view, markets regulate themselves and any government-imposed regulation induces unnecessary costs. Porter (1991) suggest the contrary perspective, that if environmental regulation is properly designed to focus on outcome instead of the method it will result in increased resource efficiency and encourages dynamic change. Porter (1991) indicates that regulation can result in radical innovations in two ways, called the 'Porter Hypothesis'. The first is through stimulating the development of new products and services by incumbents. The second way is by creating conditions that allow new producers to enter the market. However, a prerequisite for regulation to result in radical innovations is willingness, opportunity and the capacity to innovate. Development of new

technology imposed by stringent regulation gives a firm the benefit of the 'first mover' advantage and it is able to capture the market for their new technology. (Ashford and Hall, 2011; p. 277). Porter's hypothesis is criticized because it focusses on the way incumbents respond to (more) stringent regulation but ignores new entrants joining the market with their response to stringent regulation. Environmental regulation, according to Ramanathan et al. (2010), is considered a market entry barrier for new entrants due to the high regulatory compliance costs. The main barriers related to regulation are administrative burden, regulatory protection of incumbents and the complexity of regulatory protection of incumbents (OECD, 2015b).

The common scenario for regulation is that (new) standards are imposed for clean technology which is yet to be developed. The regulator has to depend on the industry to innovate in order for the regulation to benefit society. Puller (2006, p. 690) discovered an interesting phenomena that, "if for some reason the industry does not innovate, the regulator would have an incentive to ratchet down the regulation to avoid imposing an expensive policy on society." This incentivises firms to behave strategically when innovating because of the "ex post incentive to ratchet up regulation and expropriation gains from cost-reducing innovation" (Puller, 2006; p. 690). Ashford and Hall (2011) identify the concept of 'first mover advantage' that provides advantages to the firm that has developed an innovation first and can benefit from the absence of competition. Another incentive to comply with regulation through innovation is that it imposes costs on competitors as they have to comply with the new regulation (Puller, 2006; p. 691).

2.4 Economic conditions & entrepreneurial culture

For innovations to occur and to be successful, additional factors play an important role (Yu and Hang, 2010). Economic conditions have an effect on innovations, mainly because the percentage of Gross Domestic Product (GDP) spent on R&D and the availability of subsidies and grants are considered direct support mechanisms for innovations (OECD, 2015b). The capacity to innovate depends, according to Furman (2002; p. 900), on the level of spill-over effects between firms and the level of support for research or legal protection for intellectual property. A volatile financial market in which interest rates and exchanges rates fluctuate heavily, reduce investments by small and medium enterprises (SMEs), so having a stable macroeconomic would be a favorable economic condition for innovations (OECD, 2010).

A second factor that is important for innovations is the entrepreneurial culture of a country (Yu and Hang, 2010). This relates to the extent to which a country is supportive of (innovative) SME's. The OECD (2015b) recognizes the importance of innovative SMEs and entrepreneurship but at the same time acknowledges that these SMEs encounter many barriers that prevent them from fulfilling their full

potential. To overcome barriers for innovation, it is important to have a supportive innovation infrastructure (Furman et al., 2002). This includes policies for new enterprises that are lenient in terms of R&D tax, access to finance, support service for SMEs and the removal of technical regulatory barriers (OECD, 2014).

2.5 Plastic waste recycling

The production of plastic relies on the use of finite virgin fossil sources and during its lifecycle, plastic produces many negative externalities. To overcome these externalities, the goal is that plastic does not become waste, but re-enters the economy as a raw material. For creating a sustainable and circular economy for plastic, it is necessary to decrease the use of virgin raw materials and re-use as much as possible. See figure 2.2 below for a visual representation of the value chain of plastic.

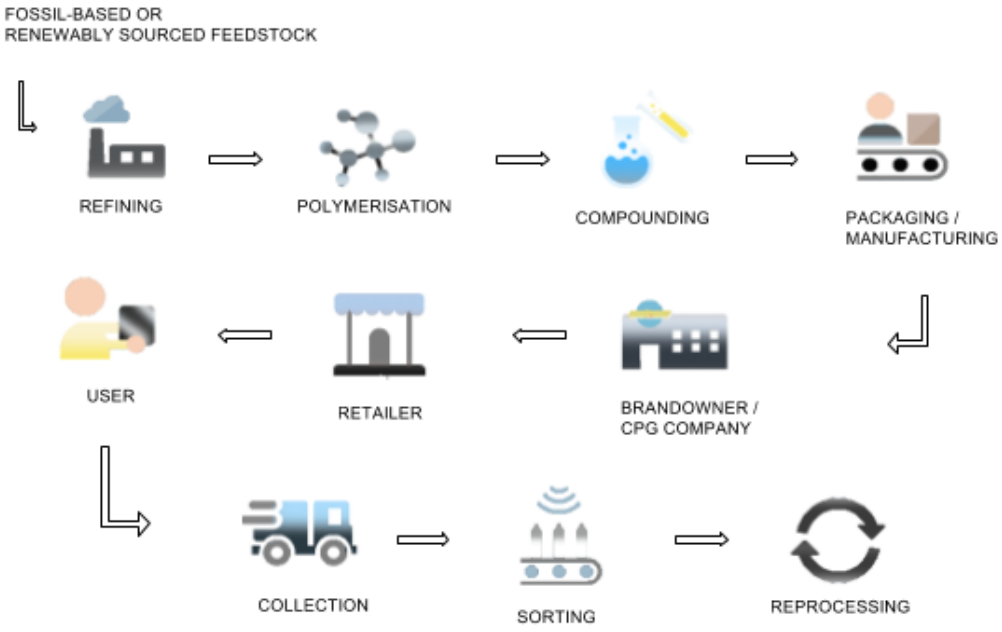

Figure 2.2: Value chain of plastic. Source: Ellen McArthur Foundation & McKinsey, 2016.

After a product is used and classified as waste, "it is subdivided into waste streams from private households and commerce as well as generated by economic activities such as manufacturing industry construction and agriculture" (Plastic Recyclers, 2017). Waste collection schemes determine the composition of the waste stream and, therefore, the suitability for downstream pre-treatment, sorting (separation) and compounding. Several collection schemes are used, plastic is collected separately or mixed with other materials. However, all waste collection schemes share the objective of maximizing recovery of recyclables and to recover the value (Plastics Europe, 2017b). Waste is collected from a variety of sources, from households, businesses, end-of-life-vehicles, electric and electronic appliances (WEEE), agricultural films and finally industrial and commercial waste. As a result of this wide variety

in plastic types present as well as variety in the condition of plastic, (i.e. degradation) pre-treatment is required. The technologies that are used for pre-treatment depend on the waste source but include manual picking, shredding, sieving and sometimes washing (Plastics Europe, 2017c). Separating plastic can be done in several ways. State of the art technologies include sink-float separation, spectrophotometric separation and cyclone density separation. Sink-float separation exploits the density of different polymers to determine the plastic as it either sinks or floats. Spectrophotometric separation uses UV, visible infrared (VIS) or Near-Infrared (NIR) to acquire spectral data on each individual piece of plastic, the spectral data are used to command air nozzles or flaps to separate the plastic into several groups. Cyclone density separation uses the difference in density to separate plastic in a rotating cylinder. These separation technologies achieve a accuracy rate of up to 95%.

Besides these state of the art separation technologies, new separation methods emerge. The demand for high accuracy separation technologies remains eminent in the recycling industry. The first emerged innovative technology, Magnetic-Density-Separation (MDS), is an alternative method to separate target from non-target based on the differences in density. By adding the plastic to the process fluid, containing nano-ferrous particles, and using magnetization "it is possible to make the liquid artificially light or heavy in a gradient magnetic field" (Hu, Giacometti, Maio, & Rem, 2011; p. 969). The low density plastic floats and the high density plastic will be at different depths, according to their density. By setting splitters at different levels, the plastic is separated (Umincorp, 2017). The second emerging technology is electro-static separation. Using the frictional charge characteristics that become apparent when different types of plastics are rubbed together (Daiku, Inoue, Tsukahara, Maehata, & Kakeda, 2001). The plastic enters a rotating drum that is electrostatically charged and separation takes place while the plastic is passing through electrostatic fields. Plastic is electrostatically separated according to their different charges.

Both technologies provide new ways to separate and aim to improve the accuracy rates of separation technologies, as accuracy is currently one of the limiting factors in plastic recycling: separating plastic with a high accuracy (>95%) and at the same time cost-effective will be attractive for the market to start adopting these technologies.

2.5.1 Recycling plastic in Europe

Plastic waste is either recycled, incinerated for the recovery of some energy or landfilled. The European Commission has defined 'recycling' in Directive 2008/98/EC as: "any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations" (European Parliament, 2008). However, Plastic Recyclers (2017) define recycling as: "any recovery operation

through which waste materials are reprocessed into products, materials or substances for their original or other purposes." Plastic recycling companies currently have to deal with different definitions of recycling.

In 2014, 25.8 million tonnes post-consumer plastic waste ended up in the official waste streams of which 30.8% was landfilled, 39.5% was incinerated for energy recovery and only 29.7% recycled (Plastics Europe, 2016a). These numbers, combined with the positive trend of favoring recycling (+64% from 2006-2014) and energy recovery (+46% from 2006-2014) and a decrease of landfill (-38% from 2008-2014), require a closer look. Recycling rates are, to a large extent, determined by geography, as well as the plastic type it concerns and the application that it was used for. Within Europe, Switzerland, Austria, Netherlands, Germany, Sweden, Luxembourg, Denmark, Belgium and Norway have achieved the highest recycling rates, in general, due to the ban on landfilling. Countries that are not achieving high recycling rates can be classified as south-, south-eastern European countries like Malta, Cyprus, Greece, Bulgaria, Croatia, Latvia and Romania (Plastics Europe, 2016a). Certain polymer types are easier to recycle, such as PET bottle, as it has very distinctive characteristics that can be used for separation and subsequently for the production of a new PET bottle. The application of plastic affects the degree to which it can be recycled. WEEE plastic contains a mixture of materials and even some hazardous materials (European Commission, 2017b) and, moreover, modern electronics contain 10% of the total gold worldwide. WEEE products are therefore not primarily recycled for the plastic but for (precious) metals.

2.5.2 The challenge of plastic recycling

There are three driving forces behind the use of recycled plastic in new products. The economic driver is reducing the amount of virgin plastic used in new products and avoiding waste management fees. Protection of the environment, saving resources and sustainability are the environmental drivers behind the use of recycled plastic. The political driver is Commission Decision 2011/753/EU, Article 11(2) which states "By 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70% by weight." Although these drivers are in place, plastic recycling is characterized by several factors that work against achieving high recycling rates. First, there is a trade-off between the technical feasibility of high recycling rates and the economic feasibility. From a technical perspective, state-of-the-art technologies are capable of separating all plastic. The recovery rate of plastics in a waste stream is in conflict with the precision of sorting. Sorting is based on separating target from non-targets, so to achieve a high precision results in an output that is not contaminated with non-targets. However, due to the necessity of high precision the recovery rate, the

amount of plastic that is taken out of the waste stream for recycling purposes, remains low. There is a trade-off between the two, and for economic reasons it is currently not feasible to achieve high recycling rates. Possibly because the market for recycled materials is not yet sophisticated and the value of recycled plastic is low. A second problem relates to the heterogeneity of the plastic that is being recycled. The inevitable countless combinations of different plastic types, the effect of degradation, shape and weight are causing problems for the plastic separators and compounders (Brendle, 2017). Another problem related to the heterogeneity are additives because "Different levels of copolymers, modifiers, or other additives in recycled material can be frustrating for those who try to combine various sources of scrap and produce a quality product" (Tolinski, 2009). Plastic waste that contains multi-layered plastics are responsible for the third problem. The combination of multiple layers of different types of plastic is problematic because detecting the different types that are present in the various layers it not possible. So separating multi-layered plastic and recycling them is not possible, although their share in the waste stream is increasing. The fourth problem arises when plastic waste is used as input material for a new product. What characterizes these products, is that they are of low quality. Due to the variety of problems mentioned, the quality of recycled plastic is not as trustworthy compared to virgin plastic resulting in primarily low quality applications. Stated differently, recycling is actually 'downcycling' because a high quality product will be recycled into a road bollard, playground tile or flowerpot after which it reaches its end of life stage as these products cannot be recycled.

2.6 Theoretical model

Based on the theoretical framework presented in this chapter the following causal mechanisms have been adopted and are translated into hypothesis to assist answering the main research question.

> H1: Policy uncertainty has a negative effect on the amount and quality of innovations for plastic recycling technologies

Development of an innovative technology requires investment. The risk associated with the investment increases with uncertainty regarding future governmental decisions. Especially environmental policies are characterized by a high level of uncertainty because of the long-term considerations and the involvement of science. A high uncertainty provides businesses with the opportunity to delay investments and therefore delay the development of innovative plastic recycling technologies.

> H2: Path dependency has a negative effect on innovations for plastic recycling as it provides little incentive for incremental innovation of the status quo

Path dependency constrains the available policy options to change existing plastic recycling regulation and it is more likely to continue on the existing regulatory path than to take a new one – even if the new path results in considerable better results. The difference between the status quo and the degree of change invoked by the policy options matters. As Haverland (2000) discovered, when the status quo is close to the proposed policy options (low adaptation pressure), there is less incentive to innovate as the goal is almost reached beforehand. The incremental change is not worth the effort. However, when adaptation pressure is high as a result of large differences between the status quo and required change, a more radical approach is adopted (Haverland, 2000). Due to path dependency, policy will evolve incremental and is not able to evolve radically. Although a restriction in available policy options would theoretically reduce the uncertainty associated with that policy, it is expected that the available options still have a high variety in outcomes and therefore does not reduce policy uncertainty.

> H3: The disadvantages of environmental regulation exceed the advantages of environmental regulation, resulting in a negative net effect of regulation on innovations for plastic recycling technologies

The benefits of regulation in favour of innovations are overshadowed by the costs of compliance that regulation induces on the industry. Although regulation can offer numerous benefits, they impose a regulatory burden on those having to comply. They have to invest time and resources into complying instead of innovating. The negative net effect mitigates innovations for plastic recycling.

> H4: Favourable economic conditions, including a growing GDP per capita, a high % GDP spend on R&D, investment opportunities and available subsidies have a positive effect on innovations for plastic recycling

Favourable economic conditions such as the relative expenditure on R&D as % of GDP, having investment opportunities and available subsidies have a positive effect on innovations for plastic recycling technologies. The stability of the macro-economy is a favourable economic condition for innovation as it allows for increased investments by SME's and stable interest- and exchange rates.

> H5: A positive, innovation-oriented entrepreneurial culture has a positive effect on innovations for plastic recycling

A positive entrepreneurial culture which is supportive towards innovations through infrastructure, innovation policy and established funding sources (R&D spending & investment) has a positive effect on innovations for plastic recycling. In addition, a lenient governmental SME policy that is supportive as well as the access to finance contribute to innovations for plastic recycling.

The figure below (2.3) presents a visual representation of the theoretical model.

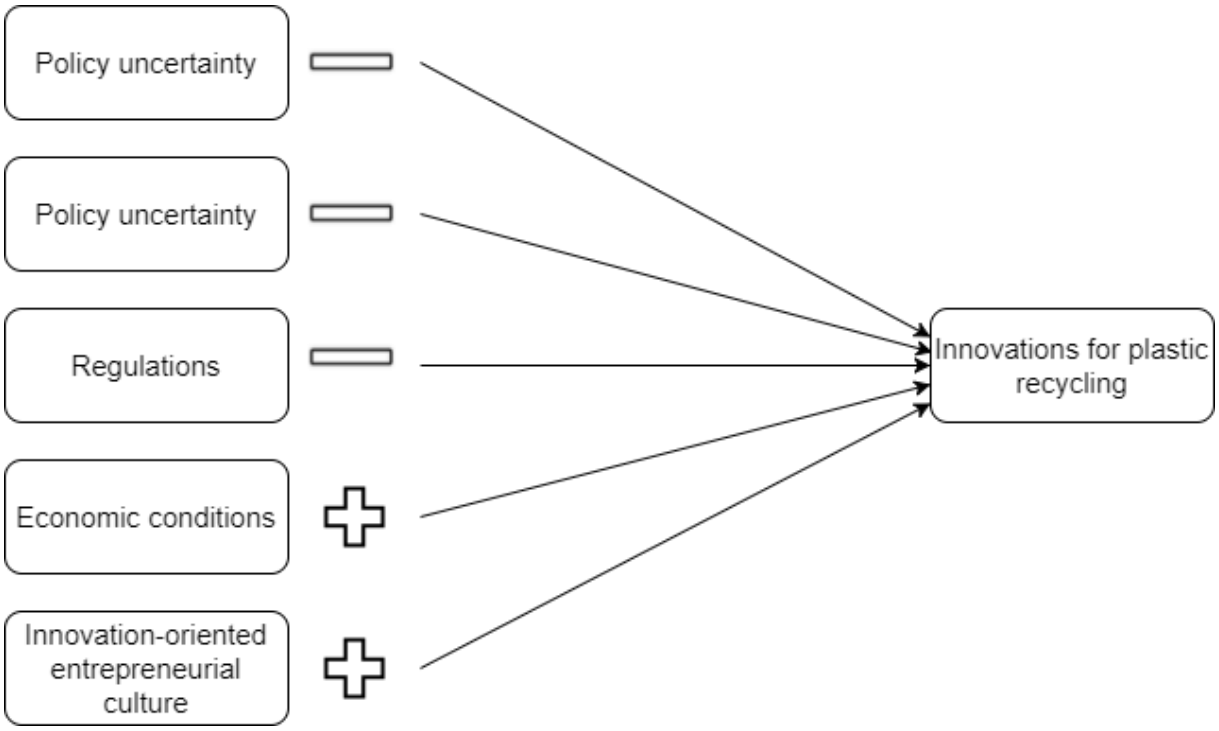

Figure 2.3: Theoretical model

3. Methodology

This section explains the methodological framework used in this study. First, an explanation is given about the research method used in this study. Then, the selected cases are integrated in the research design and the data collection method is outlined. Next, the operationalization of theoretical concepts is provided to be able to measure the collected data. Finally, a reflection concerning the validity of this study is provided.

3.1 Research method

This research constitutes of a comparative case study between two countries. The process of comparing countries is centered around four, mutually reinforcing, objectives. Landman (2008) distinguishes between contextual description, classification, hypothesis testing and prediction. Contextual description provides insights in what other countries are like. Classification decreases complexity by providing a way to organize empirical data. Hypothesis testing is used to eliminate contradicting explanations about particular events with the goal of building general theories. Finally, the results of the comparison can be used for prediction about the expected outcomes in countries not included in the comparison. The goal of comparative research is to draw inferences that can be tested in countries not included in the comparison to test to what extent the inferences can be generalized to other (EU) countries. A comparative case study provides insight in the similarities and differences between two or more selected cases (see 3.2 for the similarities and differences). The comparison of few countries is case-oriented since the analysis is focused on the unfolding of events and political developments within the selected cases (Landman, 2008). A comparison of few countries is more intensive than extensive, as the smaller sample of countries allows to research the individual cases more in-depth. The comparison of few countries is not suited for broad empirical generalizations as the analysis, and operationalization of concepts, is context specific. This translates in a lower level of abstraction of the theoretical concepts. The comparison of few countries enhances the validity of the concepts as they are operationalized in a way that captures the context of the countries being subject to comparison (Landman, 2008). For a comparative case study, two types of designs can be distinguished. Most different system design (MDSD) compares countries that do not share any common features, apart from the outcome to be explained and some explanatory factors that are important for the outcome (Landman, 2008). In contrast, a most similar system design (MSSD) is used to compare countries that share a lot of common features. As Landman (2008, p. 70) describes “MSSD seeks to identify the key features that are different among similar countries and which account for the observed political outcome”. In a MSSD, countries share the same features and the same explanatory factor. Those countries without the explanatory factor, also lack the outcome to be explained. It is thus the presence or absence of the explanatory factor that result in the outcome.

3.2 Case selection

In order to gain a better understanding of the relationship between policy uncertainty and technological innovations for the plastic waste recycling industry a comparative case study is conducted in which two countries are subject to analysis. The population for this research consists of technological innovations for plastic waste recycling. The selected countries, Netherlands and Belgium, are the unit of analysis. These countries have been selected based on their similarities in the control variable(s) and difference between the (in)dependent variable. Regarding the independent variable, policy uncertainty, the countries are scored based on the Economic Policy Uncertainty (EPU) Index in which a lower score indicates lower uncertainty. The Netherlands scores 96.39 based on the EPU Index whereas Belgium scores 134 in the EPU index. Compared to the European EPU average of 172 and large countries such as the United Kingdom (189.9), Germany (166) and France (200), both countries score below average. However, the Netherlands scores 45% lower than the European average, whereas Belgium scores 22% lower than the European average. This indicates that policy uncertainty, compared to the European average, is considerably higher in Belgium than it is in the Netherlands.

When considering the control variables, the MSSD requires similarities between the countries rather than differences. The Global Innovation Index ranks countries based on their innovativeness with a score ranging from 1 – 100. The Netherlands is ranked 9th on the Global Innovation Index with a score of 58.29, Belgium is ranked 23rd with a score of 51.97. If only the European countries are considered, the Netherlands ranks 7th and Belgium 14th. Both countries can be classified as innovative considering their high global rankings and are considered innovation-driven (Global Entrepreneurship Monitor, 2017).

The economic conditions of a country, measured in GDP per capita and the % of GDP spend on R&D activities are compared using World Bank data. The Netherlands has in 2015 a GDP per capita of $44.290 and a growth rate of 1.5%. Belgium has generated a GDP per capita of $40.544 with a growth rate of 1.3% in 2015. Both countries generate a higher GDP per capita compared to the European average of $35.099 and have a similar growth rate. The % of GDP spend on R&D activities is similar between the Netherlands and Belgium. 2.015% of GDP in the Netherlands is spend on R&D and 2.455% of the total GDP in Belgium is spend on R&D, both being above the EU average of 1.95%.

The entrepreneurial culture entails several indicators including the access to finance, number of new SME registrations and supportive governmental policy for SME's. The access to finance, which can either be a loan or venture capital investment, is ranked between 1 -7, whereas a score of 1 implies that access is difficult and 7 that access is easy (Word Economic Forum, 2016). The Netherlands scores 4.2 on access to loans and 3.7 on the availability of venture capital investment. Belgium has a score of 5 regarding access to loans and 3.8 on the availability of venture capital investment. Another indicator

of entrepreneurial culture is the amount of new SME registrations. In 2012 in the Netherlands, on average, 4.4 new businesses registered per 1000 inhabitants. In Belgium 2.5 new businesses have registered in 2012 per 1000 inhabitants (World Bank, 2017). Compared to the average of the European Union, 5.8 new businesses per 1000 inhabitants in 2012, both countries have a lower score.

The degree to which governmental policies are supportive towards entrepreneurship is scored on a 9 point scale, 1 being highly insufficient and 9 highly sufficient. The Netherlands scores 5.38 (6th out of 62 records), Belgium scores 6.48 (1st out of 62 records) (Global Entrepreneurship Monitor, 2017). The burden of governmental regulation is valued in the Global Competitiveness Report by the World Economic Forum (2016). In the Netherlands the burden is valued at 4.0, Belgium is valued at 3.2, both comparable to other European countries.

The political system of the selected cases is similar in most regards. Both countries have a parliamentary system and a constitutional monarchy. In both the Netherlands and Belgium, the king is head of state and the prime-minister is the leader of the government in a multi-party system. Both political systems allow for a coalition when forming a government. The difference between the political systems is the federal structure of Belgium that divide the country into three regions (Flanders, Brussels and Wallonia), which is not the case in the Netherlands. This difference might be debit to the discrepancy between the measured policy uncertainty in the Netherlands and Belgium.

Concerning the dependent variable, recycling rates, the Netherlands has a collection rate of 93.8% out of which 49.8% is recycled. Belgium collects 97% and reaches a recycling rate of 41.8% (Eurostat, 2017). What is important, however, is how the recycling rate is defined and calculated. This is important because the quality of recycling matters. In order to achieve circularity for plastic, recycling waste is preferred over incineration for some energy recovery and incineration, in turn, is preferred over landfilling waste. When comparing the Netherlands and Belgium differences occur. Although both countries have a country wide ban on landfilling, the Netherlands still landfills 6.2%. Belgium does considerably better with 3% landfill (Plastics Europe, 2016a). The percentage that is being incinerated is 66.7 in Belgium and 60.2 in the Netherlands. The percentage that is actually recycled in the Netherlands is 33.6 and in Belgium 30.3. As the outcome of European or national regulation results in different recycling rates which are in favor of Belgium, the selection of the Netherlands and Belgium as cases for comparison in a MSSD is justified. Although both countries are subject to European law, they have national regulation in place that translates European- to national law and/or regulation and results in different rates for landfilling, incineration and recycling. To reach high recycling rates, these countries have adopted state of the art technologies for the collection, separation and recycling of plastic waste. This research aims to provide understanding and insights in how and to what extent

policy uncertainty affects innovation and poses a challenge for the adoption of new plastic waste recycling innovations.

Due to the wide variety of actors involved when innovating, within both countries a distinction will be made between policy makers (public sector) and businesses/trade associations (private sector). This distinction is important to understand the relationship between, and effect of, policy uncertainty on innovations in plastic waste recycling technologies from both public- and private perspective.

3.3 Research design

This research constitutes of a positive and deductive study. Combined with empirical data this research aims to unfold, in an unbiased and objective way, the reality as is. It aims to improve the understanding the effects policy uncertainty has on plastic waste recycling technologies, specifically regarding why and to what extent policy uncertainty affects innovations, through linking empirical data to the concepts that are derived from theory. For this research to remain generalizable to a certain degree it is of importance to analyse the selected case objectively by controlling for other factors that might be of influence to the variation. By adopting an empirical approach, this study describes the situation as it is, in a value-neutral way. This is in contrast with a normative approach, which describes about what ought to be and includes values (Toshkov, 2015). To make a comparison between two countries, a small-N design is adopted. A small-N design allows for comparing a small number of cases, countries in this study, that consist of at least 2 observations (Collier, 1993). In general, the comparative method depends on the trade-off between the level of abstraction and the scope of countries in the study. The higher the level of abstraction of theoretical concepts, the higher the possibility to include many countries in the comparison. In contrast, focusing on two countries results in having to use concepts that are less abstract and are grounded in the context applicable to the selected countries (Landman, 2008). The results can be adopted with a normative approach as it will show how the effect of policy uncertainty influences innovations from which normative lessons can be drawn on what ought to be.

Generally, three levels of abstraction can be distinguished. The highest level of abstraction, often referred to as grand theory, has a wide scope and provides little context as the theoretical concepts are too broad to connect to a specific situation or practice. Grand theory tends to be universally applicable and generalizable which makes it very abstract. A middle level of conceptual abstraction is less abstract compared to grand theories, but address specific phenomena or concepts within a limited scope that is clearly defined and provides medium context. A middle level of abstraction allows for testing of (grand) theories by testing them empirically. It is not possible, however, to generalize these findings to the entire population. The lowest level of abstraction, situation-specific theories, has a narrow scope, provides most context as they explain specific observations and they are not universal. A primary feature is that it identifies hypothesis that deal with narrowly defined phenomena. Using a

middle level of conceptual abstraction, the comparative method allows for a good comparative analysis. A middle level approach has benefits over situation-specific theories as it does not limit the selection of the population and does not focus on a specific phenomenon that is reflected in practice. The outcomes of the comparison are, according to Landman (2008), the product of multiple causal factors acting together. When comparing the adoption of industry specific technology it is challenging to isolate the causal effect of, in this case, policy uncertainty on the adoption.

Using a most-similar-system-design, this research aims to identify how policy uncertainty has an effect on recycling rates. The findings of this research will highlight the factors of policy uncertainty that influence innovation in plastic recycling. In addition, the findings will be used to reflect on whether policy uncertainty poses a limiting factor for achieving circularity for plastic.

3.4 Data collection method

Data are collected using a variety of sources. First, semi-structured interviews are used to gain insight in the perceptions and experiences of policy-makers and plastic waste recycling businesses. Semi-structured interviews use a prepared, open-ended, topic- or question list which can be applied flexibly and leaves room for additional perspectives from the interviewee (Flick, 2014). This data collection method is chosen because the answers provide rich and detailed information and allow the researcher to adapt to the flow of the interview as the topic list is not in a fixed order. Using a topic list consistently in all interviews, the data will become more comparable and more structured (Flick, 2014). In total, 14 interviews will be conducted. One for the European Commission (representing the European Union), to acquire data on European level. For the Netherlands, two interviews are conducted with policy-makers, one interview with the trade association and five interviews with plastic recycling companies. For Belgium, one interview is conducted with policy-makers and four interviews are conducted with plastic recycling companies.

Second, in addition to the qualitative data that are derived from interviews, respondents are asked to fill in a questionnaire, consisting of several statements regarding perceived policy uncertainty and responsibilities. This second data collection method is used to approach the problem on a different level and to generate a different type of result. When comparing survey data to interview data it may lead to three types of results: converging-, complementary- and contradictory results. The survey data, therefore, serves as complementary data that provides quantitative support to qualitative statements derived from interviews. The survey data also serves as input for conducting the interview as the results can be referred to during the interview. In the case of unexpected answers, being able to ask for an explanation or elaboration in the interview provides valuable additional context besides the quantitative data. To complete the data triangulation, documents are used to gain preliminary knowledge about policy goals, -instruments, perceived problems and possible solutions.

Data sources for policy uncertainty include the Economic Policy Uncertainty (EPU) Index for the Netherlands and Belgium as well as interviews with representatives from public- and private entities regarding the perceived uncertainty. Data on path dependency are acquired two-fold. First, policy documents provide insight in the decision-making process, the consideration of certain policy options and the involvement of incumbents in the process. Additionally, interviews are used to gain insight in the perceived degree of change due to policy as well as the effects of incumbents being involved in the policy-making process. These data are translated into a qualitative judgement on the extent to which path dependency allows for incremental or radical policy change. Data for regulatory burden and –complexity are acquired from the Global Competitiveness Report (2016). In addition, interviews are providing additional data on the perceived burden and complexity of regulation. Interviews with public policy makers as well as policy documents give insights the intentions of policy makers. For data on the economic conditions in the selected country's the GDP index of the World Bank provides statistical data for economic growth and the national % of R&D spending in GDP. Furthermore, interviews are used to acquire data on the perceived investment opportunities by businesses. Regarding entrepreneurial culture, data are acquired through policy documents, including the Global Entrepreneurship Monitor (2017) for government supportive policies. World Bank data is used for the number of new SME registrations and interviews provide data on the access to finance and governments lenient policy towards SMEs. Data sources for innovations in plastic recycling technologies include statistical analysis by Plastics Europe (2016a) on the degree of incineration, landfilling and recycling. In addition, interviews are conducted to provide insights on the use of recyclate in new products and trade-offs between accuracy and recovery rate.

3.5 Operationalization of key variables

The table below describes the key variables and their operationalization including indicators and the methods used for the measurement of variables.

Variable	**Definition**	**Indicator**	**Measurement**
Independent variables			
Policy Uncertainty	Government's future path is uncertain	1. Stability of the political regime 2. New regulation & amendment proposals 3. Frequency of references to policy uncertainty in newspapers	Policy uncertainty is measured using the EPU index. *Interval/ratio* Interviews using Likert-scale ranging from 1-9 to rate: "public policy regarding plastic waste regulation is uncertain" Perceived policy uncertainty - Interviews

Path dependency	Initial decisions in a certain direction elicit further decisions in the same direction	1. Decisions are based on historical decisions and current legislation 2. Policy options are limited 3. Incremental change due to risk aversion 4. Incumbent influence policy options as they benefit from status quo	1. Rationale of policy makers *Nominal* 2. Considered policy options and why *Nominal* 3. Perceived change of policy for businesses scaled 1 – 5 *Ordinal* 4. Degree to which incumbents have been involved in various phases of policy making scaled 1 – 5 *Ordinal*
Regulation	The regulatory framework of a country affecting the process of plastic recycling & innovation	1. Regulatory burden 2. Regulatory complexity 3. Regulatory intensions towards innovation 4. Negative externalities of regulation	1. Perceived regulatory burden. *Ordinal scale 1 – 5*. *2.* Perceived regulatory complexity. *Ordinal scale 1 – 5.* 3. Perceived externalities are measured through interviews. *Nominal scale*.
Economic conditions	The economic environment of a country	1. Economic growth (GDP per capita) 2. National R&D spending 3. Investment opportunities 4. Available subsidies	1. GDP per capita index on *interval* scale 2. The % of GDP spend on R&D *Interval/ratio* 3. Perceived investment opportunities using interview/survey 4. Number of subsidies *Ordinal*
Entrepreneurial culture	The extent to which a government is supportive of SMEs	1. Lenient governmental policy for SMEs 2. R&D transfer 3. Access to finance 4. New SME registrations	1. SME policy index scaled 1 – 5 *Ordinal* 2. Support services for SMEs scaled 1 – 5 *Ordinal* 3. Access to finance scaled 1 – 5 *Ordinal* 4. Number of new registered SMEs *Ordinal* 5. 'Rank the degree to which the government is supportive' on Survey question *Likert scale 1 – 9*

Dependent variable			
Innovation in plastic waste recycling technologies	New innovative technologies that improve the accuracy of sorting or allow high recycling rates for reprocessing	1. Reduced amount of virgin plastic used in reprocessing 2. Increased recovery rate for sorting in an economically feasible way 3. Decrease % of plastic that is incinerated or landfilled 4. Adoption of recycled plastic as quality secondary raw material	1. Use of recycled plastic in new products 2. Recovery rate vs. Accuracy *Ratio* 3. Amount of plastic recycled, incinerated and landfilled *Ratio* 4.

Table 3.1 Operationalization of key variables

3.6 Validity

In qualitative studies, validity relates to whether the researchers in fact see what they think they see (Flick, 2014). Three types of errors may occur: See non-existing relationships or identify relationships inaccurate (type 1 error); reject relationships when they are correct (type 2 error); and finally ask the wrong questions (type 3 error) (Flick, 2014). The matter of causality, external validity, in case of small-N research is debatable. The threat to external validity is the extent to which the causality presented in this case represents the population as a whole. In this research, it is questionable that the causality between the independent and dependent variable represent the causal relationship of the independent and dependent variable for the entire population of technological innovations for plastic waste recycling.

The external validity of this research is considered low because the results cannot be generalized to the entire population, consisting of all countries, based on a single cross-country comparison. In contrast, the internal validity of a qualitative research is relatively high since this research is an in-depth analysis of a single case (Verschuren & Doorewaard, 2007; p. 191) and a multiplicity of data sources is used which are related to the same subject. Each respondent will be asked to fill in a questionnaire in addition to the topic to be discussed from the topic list. Selection bias might pose a threat, but with carefully selected unit of analysis, based on a most different design system, this threat is limited. Another threat is the interaction effect, which translates into the independent variable having an effect on the dependent variable through a third, moderating variable. Not taking this moderating variable into account may result in drawing inferences that are not correct. To overcome this threat multiple variables are included to test for possible interaction effects between the variables and to ensure drawing legitimate inferences.

For the private sector this research targets companies that are active in collection, sorting and/or reprocessing plastic waste. As has been mentioned before, from a circularity perspective, the entire

value chain should be taken into account to address the issue. However, due to time and geographical constrains this is not deemed realistic. This presents a limitation in terms of generalization of the findings to the 'entire' industry of plastic waste recycling as the findings can be linked only to a specific part of the value chain . Therefore, the reader should be aware of generalizing the findings to the entire plastic recycling industry, which consists of more than is analysed in this research.

Another limitation of qualitative research using semi-structured interviews is related to the interpretation of the collected data (Flick, 2014). This requires a researcher to be systematic and consequent in coding the interview transcripts and translating them into data that can be used for analysis.

4. Analysis

This section presents the findings of the 14 in-depth semi-structured interviews that have been transcribed, using quotes in italic. First, the participants are introduced shortly. This is followed by the presentation of experiences and perceptions of the European Commission, the Dutch government, the Belgium government and plastic recycling companies. The quotes are presented for each theoretical concept individually. Finally, the quantitative results of the questionnaire will be described.

4.1 The participants

The participants of this research can be categorized into different groups. The European Union is represented by the Directorate-General Environment of the European Commission, the Belgium government is represented by the Public Waste Agency of Flanders (OVAM), responsible for plastic recycling in Flanders. The Dutch government is represented by the Ministry of Economic Affairs and by the Ministry of Infrastructure and Environment. In addition, the Dutch association for Plastic and Rubber (NRK) represents the plastic recycling sector in the Netherlands as a whole. The remaining 9 respondents consist of a variety of companies active in plastic recycling, performing different aspects within the value chain in either the Netherlands or Belgium (or both in case their business is cross-border).

4.2 The perceived policy uncertainty

On a European level, as a policy maker of the European Commission '*you try to project policy based on a reasonable future, with 2050 usually being the point of reference. This is considered normal as 30 – 40 years is not that far away. Based on the future projection, a policy direction is chosen in which policy will evolve and over time new in-between steps are required to further specify that direction*'. To support the development of policy in the chosen future policy direction, '*the scope of EU policy is based on a relative short- to mid-term timeframe, between 2-3 and 7-8 years. Although it is inevitable that not all details are correct and all exceptions have been included beforehand, it does provide certainty in terms of direction*'. This emphasizes the long-term perspective the Commission has adopted. The direction of EU policy, of which companies should be aware, *'it's clear that the required changes are related to resource-efficiency and circular economy*'. As the long-term vision of the EU is described in strategy papers '*I believe it is very unlikely that within a 1-year period uncertainty is caused by policy*'. However, there is an exception: '*The only case in which policies are changed overnight is when it concerns toxic materials that are being banned through regulation. But even in those cases, there is no real uncertainty as these companies know that they are working with toxic materials and that the direction of EU policy is to lower the tolerance for toxic materials in recycling*'. Considering that the Commission provides information on their long-term vision, through strategy papers, the Commission does not perceive the policy regarding plastic waste to be uncertain, as companies can anticipate on

the vision adopted by the Commission. Especially '*since I believe that only a very few people will be surprised by this vision*'.

The government of the Netherlands translates European directives into national law- and regulation. As a result of using directives as the basis for national law- and regulation '*the norms are formulated in such a way that it allows for multiple interpretations, resulting in a variety of different norms throughout Europe*' and '*the definition of recycling is one example, which results in different ways to calculate the percentage of plastic waste recycling*'. The evaluation of the waste- and packaging directive is '*aimed to create a level playing field within the European Union*'. The creation of a level playing field is necessary considering that '*some countries went to create very complex calculations to determine the recycling rate, in some cases they achieved more than 100%*'. The '*definition of recycling has a large effect on the recycling rates of countries. Germany calculates their recycling rate based on the amount of collected plastic waste whereas the Netherlands calculates the recycling rate based on the amount of plastic waste that is provided to the recycler*'. Another implication of different definitions is that '*what is considered waste in the Netherlands, is considered feedstock in Germany*'. To reduce uncertainty '*the differences between countries need to be aligned. This poses a huge challenge as changing the definition of recycling will affect the recycling rates of certain countries negatively*'. The government of the Netherlands does experience uncertainty caused by the European Commission as '*the Commission has proposed to increase the recycling rate to 55%. Whilst the European Parliament wants to increase this even further, South-European countries advocate to lower the percentage. Because we do not know what the decision will be, there is no way we can anticipate beforehand and, consequently, reduce uncertainty for the industry*'. The proposed goal of 55% recycling '*provides a perspective to base policy upon, however, without incentives from the EU to achieve higher recycling targets it will be difficult to 'sell' the policy nationally' because these goals are not ambitious for the Netherlands*'. Another cause of policy uncertainty relates to eliminating regulations that are restricting plastic recycling, such as the EU wide definition of waste. '*Changing the regulation regarding, or definition of waste is very difficult. Although the intention is there to change, reality shows that it is very difficult. The uncertainty about this issue results in a deadlock as the establishment is not willing to change and neither are the producers of plastic products that could use recyclate willing to actually use it*'. In the current situation, *'waste incineration facilities contribute to this deadlock and provide perverse incentives as they have to import waste to incinerate*'. The question is '*whether or not we should re-design the system, e.g. harmonize public policy*' because there are contradictories between policies of different ministries. '*The solution would be to combine the policies and adopt an integral approach but this is usually not possible due to the complexity and political dimension*'.

In Belgium, the OVAM is responsible for translating European plastic waste policy to regional policy for Flanders. Within Flanders, policy uncertainty is limited '*for companies active solely in Flanders because everyone follows the same line of reasoning and the companies involved with plastic recycling are well informed about the way OVAM works*'. Broadening the scope beyond Flanders results in a different situation, partially caused by the wide variety of systems and definitions used by neighbouring countries. This results in more policy uncertainty. '*The uncertainty is bigger for companies that are working together with foreign companies (or have subsidiaries active in a different country) as each country has a different system which is hindering their capability to recycle. Besides the limitations, it gives rise to questions regarding transport and processing waste and the extent to which the activities are compatible with local legislation*'. Policy uncertainty has effect on a daily basis, but has an effect on the long-term as well. '*As we are waiting for the Commission to decide on the threshold value of lead that is allowed to be present in PVC. For the time being, we turn a blind eye to this issue which provides PVC recyclers some certainty on a daily basis. The long-term uncertainty remains imminent as it may turn out their activities are not within the legal boundaries anymore*'. At the same time, '*companies that want to scale-up internationally are restrained by the huge amounts of paperwork required for licences to transport and process waste*'. In the case of PVC recyclers, policy uncertainty affects their long-term strategy. '*It affects the continuation of their business, as it is highly uncertain whether or not in 1 year it is (still) allowed to recycle PVC that contain a certain percentage of toxic materials. As a result companies do not invest in upscaling their capacity, they postpone investments*'.

Plastic recycling companies are confronted with policy uncertainty in a variety of ways. First, '*the government's position is ambiguous because they want to increase the amount of recycled material but at the same time they want to increase the traceability of materials and register the chemicals that are present in waste stream*'. To guarantee the traceability of materials, plastic recyclers have to be in compliance with the Regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). The purpose of REACH is to reduce the risks for consumers and the environment and includes restrictions regarding the use of additives and/or toxic materials. From the perspective of plastic recycling companies '*REACH is especially problematic for old waste streams*' and to be REACH compliant '*is simply impossible*'. The risk that is associated with certain materials is determined by the government '*as they decide the maximum parts per million (PPM) that is allowed in certain waste streams*'. What is causing policy uncertainty is that '*deciding on the maximum PPM allowed results in years of discussion and a continuous struggle*'. Another cause of policy uncertainty can be traced to the current segmentation between household- and industrial waste. '*Industrial waste has been recycled for a long time, as opposed to household waste (especially consumer packaging waste)*'. To boost the recycling of household/consumer waste '*the system of collection and processing of*

household waste is paid for by the consumer through waste disposal fees, which poses an unfair advantage for household waste recycling compared to industrial waste, as the system is paid for'. As it is unknown how this will evolve, the policy uncertainty resulting from the difference in system relates to whether the system will be maintained, and if not, how it will change.

Certainty and stability are characteristics companies are looking for. Subsidies, a widely used instrument in plastic recycling, are ought to provide certainty for the duration of the subsidy period. However, subsidies have a temporary character because '*even in the case a subsidy has been granted for 10 years, providing certainty for development, someone can decide to cut it halfway*', resulting in even more uncertainty. Especially the market of plastic packaging recycling is heavily subsidized, which '*is the reason we do not enter this market because if they decide to stop with providing subsidies, your investment is gone*'. Investments, or the decision to invest, depend on the implications of existing laws and regulations and require, preferably, stability. However, '*for a long time there has been a tax on landfilling waste, €80 per tonne, which has been lowered to €0 as a result of politics and one year later it was raised to €13 per tonne. These yoyo effects say a lot about whether or not companies dare to invest*'. Sudden changes in law and regulation can have devastating effect, resulting in '*a situation in which I won innovation awards for a technology but the next day I was committing an economic crime, since it concerned hazardous waste*'.

One of the main causes of policy uncertainty perceived by plastic recyclers is the consideration that '*over the past 20 years plastic recycling has been driven by the push effect*'. The push effect works quite well '*until there is a crisis, like we have right now, with the virgin polymer price being so low*'. To stimulate recycling, pull effects are necessary. This is supported by the belief that '*integrating certain percentages of recyclate in new products will increase the demand for recycled plastic*' and '*if there is a pull effect from the market, we will invest to increase our capacity, without these effects we will not invest*' and '*what Europe has not been doing, is to invent pull effects. Like being obliged to integrate 20% of recyclate in your new products. This is lacking now, these pull effects*'. In the absence of pull effects and considering that recycled plastic has to compete with virgin, '*having a steady demand is very important for plastic recyclers as it provides certainty and therefore influences their decision to invest, either in innovative technologies or increasing their capacity. The presence of pull effects would create extra demand*'. In the absence of pull effects, '*the investment attitude of plastic recyclers has changed to short-term economic gains and have become reluctant to invest due to the uncertainty regarding the legality of their business model in the near future*'.

The differences between EU member states in terms of regulation, waste definitions and waste systems are causing uncertainty for plastic recyclers, especially for small companies, because it is

difficult to stay informed about decisions and developments in all countries. '*It should not be the case that Belgium requires a different license than Germany*'. This places an unnecessary burden on plastic recyclers.

4.3 The development of plastic recycling policy

The perception of the European Commission regarding the development of plastic recycling policy can be traced back to the European waste policy, which is one of the oldest directives and plastics is a part of the European waste strategy. '*I do not know why we, historically, work with directives. In general it is because of subsidiarity principle*'. As a result of the historical decision to work with directives, which allows countries to make their own national laws to reach the European goal set in the directive, '*the situation today is very fragmented and this situation makes it even more difficult to start with a regulation as it is so fragmented*'. Although it is acknowledged that '*for companies, especially those doing business internationally, it would be very beneficial to harmonize policies*'. The Commission considers '*subsidiarity as a strong concept, like regional diversity*' which is the main reason to keep working with directives. The policy regarding plastic recycling drafted by the EC includes '*several legislative provisions that impose targets on certain parts of the value chain, in which packaging waste is considered predominant as it represent 60% of the waste. The existing policy is mainly focused on output, the percentage that is actually recycled*'. The current proposal of the Commission is to '*increase the recycling targets to 55%, considering it has to be realistic and feasible for the member states to reach the target, which is for some countries relatively easy compared to others. The strategy is to increase our efforts in assisting companies to reach the 55% and at the same time keep progressing (go beyond 55%), not just for packaging but for other plastics as well*'. In the future, the Commission is convinced the model should become circular which translates, in the plastic case, to '*extent the life of plastic products, use more recyclate, use renewable energy in the recycling processes, create high quality recyclate and stop down-cycling*'. This requires '*the development of technical innovations to mix recyclate and use it in high quality new products*'.

The perception of the Dutch Government on the development of plastic recycling policy is that '*the attention for plastic recycling has definitely increased as well as the interest of the industry to actively participate. In 2007, when the framework agreement for packaging waste just started, the participating companies' attitude was to stay far from it whereas I notice now that, because of the Extended Producer Responsibility (EPR), companies are convinced of the need to become sustainable and act accordingly*'. The framework includes agreements on who is responsible for collecting, sorting and selling the recycled plastic. '*As a result of municipalities having individual responsibility there are just as many different local waste systems as there are municipalities*'. The plastic recycling policy of the last 5 – 10 years is described as '*not steady at all*', '*preserved*' and '*it is important to ensure that*

the direction of energy, climate and sustainability policies are the same'. The contradictory policies and the local variety of waste systems '*are the result of trying to develop an integral policy for waste*'. This does not limit itself to the Netherlands, '*European legislation can be limiting, however, the high variety in the waste market is a bigger problem. Considering that it is an international market, it cannot be that the Belgium government requires a different licence than Germany or the Netherlands*'. In addition, historical decisions still have effect on current policy and practices, considering that '*we are currently importing waste to incinerate, which is a very perverse effect. Especially since it's all considered waste and not raw materials. Lock-in effects have to be prevented, in the '80's our waste incineration facilities were state of the art and considered a very good solution but they are now hindering recycling*'. Another example is '*the co-firing of bio-mass, which is heavily subsidized, can be considered a political choice and not a choice based on circular economy, the same could be argued for solar- and wind energy which profited from heavily subsidized programs. Government regulation is always lagging behind innovations*'. In the current Extended Producer Responsibility (EPR) system the producers are responsible and have to pay, regardless of the degree to which the packaging is sustainable (e.g. easy to recycle, made from recycled material, etc.), a fee based on quantity of plastic put on the market. '*A packaging producer should be rewarded for bringing recycled materials back into the value chain. Companies who apply recyclate in their products should be rewarded for that, thereby creating value for recycled plastic which allows for the development of plastic recycling chains*'. To simply reduce the amount of plastic that is put on the market might not be the most effective way to fight the negative externalities of plastic, which is exemplified by the ban of free plastic bags. '*The fact that prohibiting free plastic bags results in 80% less plastic bags is evident, however, the question is what is the net result? The alternative, paper bags, should be considered as well*'. Considering that the plastic bags '*contained 90% recycled material*' and were easily recyclable as they are not contaminated, the ban is more symbolic. Besides, with this ban '*the market for recycled Low-density polyethylene (LDPE) has dropped because one of the biggest customers for recycled LDPE was a producer of plastic bags*'.

For the Belgium government, the development of plastic recycling policy is divided between 3 regions: Flanders, Brussels and Wallonia. The plastic recycling policy of Flanders is described as '*mainly complex, considering the diversity of applications for polymers it is impossible to generalize for polymers*'. In Flanders, '*as stated in old legislation, something is classified as waste at the moment a company disposes something which cannot be sold as a product*'. However, in order to process material that is classified as waste companies need a license '*which is defined in our waste processing legislation. For companies that consider 'waste' as resource it is unexplainable why they need a license to process waste, as they are considering it as resource*'. Secondary materials may be classified as such '*if the*

materials satisfy certain criteria. For many materials it is clear what the product composition requirements are. For plastic, the composition requirements are non-existent'. The reason for the Belgium government not to come up with these requirements is because '*we have too much faith in European regulation which states that plastic is not waste but feedstock. As soon as this regulation is published we intend to implement it without making any changes to it, however, the EU is taking their time determining this new regulation*'. As a result of the large share of recyclable plastics that end up in the normal waste stream, which is incinerated, '*we have proposed to selectively collect plastics. This not only applies to industrial waste but also to household waste. We expect more legislation that relates to waste collection, which is also relatively easy to start with considering the influence we have on the different facets*'. As a result of the complexity, '*policy is aimed at specific parts which allow for fast and easy results*'. Green procurement is a tool which can be used by governments to set an example for the use of products containing recyclate. '*That is indeed something we are working on. For Flanders, as well as the federal government, the public procurement is centralised in a single institution. We are pushing those institutions to prefer sustainable options but as it concerns the tax payer's money, price is merely one of the many aspects. In addition, according to Belgium law, we can only change the tender requirements if there are at least three companies on the market that can supply the products. If this is not the case, we have to apply bonus points to products containing recyclate*'. Regarding future policy, '*we proposed a law that makes it mandatory for both companies as well as households to selectively collect plastic waste to reduce unnecessary incineration*'. In addition, '*although it is not within our authority to make it mandatory to integrate recyclate in new products, we are convinced this should be imposed. The other regions are not in favour, unfortunately*'.

For plastic recycling companies, the development of plastic recycling policy is described as '*weak, although there have been some changes (e.g. increased recycling targets). I believe governments opt for the safe side, they have a risk-averse attitude. Although the policy is clear (e.g. collecting consumer waste is a responsibility of municipalities) it does not result in increased collection rates. I would describe it as incremental change*'. This view is supported by '*we see an increase in government involvement as they need to reach their targets*', '*a conservative system which originates from the '70s' and 'policy is the result of lobbying, which is a form of corruption as it is unfair*'. Although the direction of policy is clear by focussing on collection and sorting, implications of certain decisions can be far reaching. '*In 2005 Germany suddenly prohibited to landfill directly and increased the price of incineration. As a result, the Netherlands had a surplus of waste for incineration and not enough capacity. This situation benefits recycling. However, the minister of Environment decided to lift the ban on building extra incineration capacity, resulting in an increase from 4.5 million ton capacity to 9 million ton. In 2008 it was decided to somewhat limit the capacity to 7.5 million ton, which is the current*

capacity. As a result of the increased capacity we have been importing waste (1.5 million ton annually) since 2011 and the price of incineration for municipalities has dropped with 50%. Municipalities prefer the cheaper solution, incineration, which is not at all beneficial for recycling'. Another policy which had far reaching implications is the introduction of Annex 7 by the European Union. '*This document includes information relating to where we buy, to whom we sell, the processes involved, which carrier was used etc. Because this information was publicly available, I lost my competitive position*'.

The plastic recycling companies believe the government has a clear focus with regard to plastic recycling. '*The increased involvement of the government can be explained as they need to meet their recycling targets, which are being raised. However, the government focuses completely on collection and a little bit on sorting. The ultimate goal, recycling (in my opinion that is using waste as feedstock), does not receive attention as the government's current definition of recycling is basically collection*'. The focus of the government on collection becomes clear when considering that '*based on a historical decision to target packaging it was decided to subsidize collection and sorting, but not reprocessing*'. The problem is that '*the industry has become used to and dependent on subsidies, making it very difficult to change as any proposal that challenges the status quo will be heavily opposed if it concerns financial implications*'. The industry describes subsidies as '*usually not the most efficient way to spend money*', '*a lottery, and even if you win there is a chance that the subsidy will be cancelled halfway*' and '*the reason why we never invested in the market of recycling packaging, because the moment the subsidy stops, you're stuck with your investment*'.

Plastic recycling policy has for the '*past 20 years been driven by push effects. There was some European legislation pushing plastic packaging to be recycled, mostly through EPR legislations*'. The push effects '*are focussed on increasing collection and allow citizens to separate waste*' and it is expected that '*the push effect will increase, as the obligatory quota to recycle plastic packaging will go from 22,5% to 60-65%*'. There are some negative externalities of these push effects '*pushing worked, quite well, until the price of virgin is so low that the benefit of cheap recyclate ceased to exist*'. This is exemplified by '*green procurement. A civil servant from a municipality told me about a tender and he said "The other one was a bit cheaper". This is not helping recycling or recycling companies in any way if price remains the most important criteria*'. At the same time, there seems to be movement towards a direction that invokes pull effects instead of push effects: '*there is discussion on lowering the price for bottles that contain recycled material. Officially this is not correct, however it is a good way to promote recycling*'. A solution to stimulate recycling and innovations would be to '*to implement pull effects. This pull effect is lacking in Europe now. Pull effects should result in an obligation to integrate 20% of recyclate in new products*'. This view is strongly supported: '*It should be the case that legislators prohibit products that do NOT contain a certain percentage of recycled plastic*', '*without obligations, it is too easy for*

companies to use virgin material instead of recyclate' and '*the moment virgin producers realize there are economic gains/incentives when using recyclate, progress will be easy*'.

The expectations with regards to the future of plastic recycling policy are to further increase recycling. '*The government will definitely change the definitions so that recycling becomes actually recycling*'. Considering that '*the rationality of companies is economic, innovation will only occur if they benefit from it (economically), so by providing a discount on sustainable packaging we will boost recycling. Currently the emphasis is on punishment while it could also be on rewarding those who produce products that are easily recycled and/or contain recycled material. It will require investment from the government, as the current system pays for itself*'. There is a contradiction that is not beneficial for recycling related to '*green energy, incineration and Circular Economy. In order to reach a circular economy, incineration has to stop, but in turn the circular economy in general is thwarted by the fact we do not produce enough green energy. Stopping incineration will boost the circular economy but at the same time reduce the amount of green energy producers. There is a trade-off*'. It is also expected that '*norms that currently exist on local level will expand to national level, especially for using a certain percentage recyclate in products*'. Imposing a top-down obligation to use recyclate results in '*innovations on the side of the producers of products as well as they have to cope with qualities that are not exactly the same as virgin plastic*' as well as '*investment in extra capacity, but without a pull effect we won't invest*'. In addition to the obligation to integrate recyclate '*we speak a lot about green procurement, but it is not an obligation yet and therefore no legislation exists which includes criteria for comparing offers*'.

4.4 The regulatory burden associated with plastic recycling policy

The European Commission, responsible for proposing new legislation and implementing decisions, has no experience related any burden resulting from regulation. It is unclear, from the Commission's perspective, how and to what extent companies had to adapt to the policy changes and the associated burden as '*I do not know what policies have influenced companies and how that is translated to burden associated with regulation*' but, '*one thing is certain, they must adapt to new laws and regulation, whether incremental or radical. It is at the core of policy, to realise change*'.

The burden of regulation that is experienced and perceived by the government of the Netherlands can originate from European policy or national policy. '*European legislation can sometimes be a limiting factor, however, the variety in the waste industry is causing more problems*'. Plastic recycling is considered '*an international market, but the legislation is not. In an international market it cannot be the case that companies are required to have a different license for each European country'*. The government is aware that legislation is '*considered a burden for companies. But on the other hand the*

entire waste system is built on legislation and would be non-existent without legislation'. The burden for companies is understood because '*looking at all requirements for packaging I can imagine the burden. It is a long list of norms and requirements*' and at the same time '*companies want to stop contradictory policies, which can only be supported, although it should be considered that there are so many societal goals that it is almost inevitable*'. Municipalities, who have to deal with and are held accountable for recycling, are experiencing regulatory burden. '*The protocol which describes how to administer and which protocols should be followed has grown to a book with 800 pages. This is a burden as it is unclear for municipalities how they will be evaluated and how the percentage of recycled material is calculated*'. To limit the regulatory burden for companies '*I plead for more EU legislation. In addition, we should adopt the approach that is common in the UK: they accept licences as long as it originates from a EU member state*'.

For the Belgium government, the perceived burden from regulation has multiple causes. Local governments, e.g. Brussel, Wallonia, are '*hindering any proposal coming from us if it becomes more difficult to recycle for companies from Brussels or Wallonia*'. Within current legislation, the legal constrains '*relate to the required licences to operate, composition of materials and emissions*'. Especially, regulatory burden is experienced '*if companies want to scale-up and do business internationally, they are required to process loads of paperwork before they are allowed to transport and/or process waste cross border*' which is caused by '*the fact that each country has a different system in place, with different rules and regulations*'. To reduce the burden of regulation, the composition of waste streams is important because '*if the material has a certain composition, it is classified as a secondary material. In this way, companies do not need a license to process waste*'. However, '*for polymers, the requirements of the composition in order to be classified as secondary material do not exist. We are waiting for the Commission to propose legislation that prevents polymers being classified as waste materials*'.

The perception of plastic recycling companies regarding the regulatory burden is that '*the influence of legislation in our sector is very strong. If legislation changes, or the interpretation of it, it has huge consequences*'. Basically, '*without legislation from the government, the entire recycling industry would not exist*'. Although in some cases, legislation applicable to plastic recycling is not necessarily beneficial for recycling. This is supported as '*the EU decided that if a company is working with waste, it needs to be registered as a recognized processor. Every country has their own interpretation for being a recognized processor. Belgium requires registration at OVAM, which takes only 10 minutes and 1 form. In the Netherlands, registration takes multiple weeks and is only valid in the Netherlands. In practice, every day there are several truck drivers that transport waste for us, but those drivers are not registered of course as they are from Bulgaria or Spain*'. The strict enforcement of rules is the result of health and

food related incidents in the past, but in practice, this is not workable. '*There are examples of products that have good quality but are hard to put on the market due to restraining governmental norms or regulations, as was experienced during the recycling of foam from matrasses*'. Another example is '*a box in which medical waste is collected and incinerated. This box is made of post-consumer material, however, we are facing the problem that it is not allowed to use post-consumer material because somewhere in the norm it says that such a box is only allowed to be made from recycled barrels*'.

Another challenge and burden for plastic recycling companies is the absence of an '*official transition from waste to resource*' because '*there are no end-of-waste criteria on a European level which determine when plastic is not considered waste but raw material*'. In the absence of end-of-waste criteria '*the end-of-waste stage is the grey zone if you're developing any kind of recycling process. As you want to be acting and do marketing in line with legislation, you have some grey zones that are maybe not scaring SME's but may be scaring big corporates because you are responsible for what you put on the market*'. The practical implications of not having defined end-of-waste criteria for plastic recycling companies result in situations in which '*if I sell materials, I have to notify the authorities because I have to pay a contribution (waste disposal fee). During transport, there is a magic moment when waste has become a resource! This is necessary because my customer, a producer of plastic products, does not have a license to process waste*'. This problem extends to the software used to keep track of the incoming waste and the contribution that is due. '*My software is not able to handle the fact that I buy plastic waste, which I process and sell as material. Because waste needs to be logged if it is disposed*'. Another practical implication is that '*the simple question: is it a product or still waste? Is producing thousands of pages of legal analysis each time you put a product on the market. For development and innovations, this is a nightmare*'.

In 2007 REACH was introduced stating that all materials can be traced back to their origin. REACH compliance '*is something which producers of recyclate struggle with. How do you answer to this compliance?*' In practice, REACH restricts companies in their capability to recycle because it is '*not possible to be compliant. The pellet I create is made from many products which makes it impossible to be trace back where the material originated from*'. REACH has, in the case of PVC recycling, implications because '*EU ministers decided that if old products contain > 0.1% zinc or lead it should be classified as hazardous waste*'. In order to transport and/or process hazardous waste, the regulation, rules and norms are much stricter compared to non-hazardous waste. To acquire the license for hazardous waste, permission is required from the municipality, as it should be included in their local development plan. '*Because companies do not believe they are processing waste, their attitude is recalcitrant since being classified as waste processor has negative implications on their (brand) image. Especially considering that the logo you are obliged to put on the product is a skull*'. The REACH compliance can,

to a certain extent, be avoided by '*having the buyer sign a letter that states he is buying materials and not waste. Although it is unknown if this will hold in court, this is a temporary solution that can be exploited as a result of the end-of-waste criteria grey-zone and the fact that enforcement allows it*'. Besides that, current legislation is not suitable for the use of recyclate in new products as '*there are very stringent rules of using recyclate in consumer products. In the case of PET it requires a very chemical process to remove any bacteria of which the costs are very high*'. This is not contributing to the use of recyclate in new products.

4.5 Questionnaire

The results of the questionnaire, an addition to the interview, are presented below. Regarding the degree to which public policy regulating plastic waste recycling is uncertain, the average is 5.29 among all participants on a 1 – 9 scale. Looking closer, it shows that the European Commission as well as both Dutch and Belgium governments perceive the uncertainty to be lower (respectively 2, 4.5 and 3) when compared to the plastic recycling companies in both the Netherlands and Belgium who, with an average of 6, experience a different degree of policy uncertainty.

The perception about the degree to which plastic recycling policy is subject to changes is fragmented. The European Commission and the Dutch government do not experience frequent changes as they respectively score 2 and 4 on a 1 – 9 scale. However, the Belgium government does experiences frequent changes, with a score of 8. The plastic recycling companies have an average score, with only a small difference between the Netherlands and Belgium, respectively 5.17 and 5.75.

The extent to which large companies want to be involved in the various phases of policy making is on average 7.36. Notably are the differences between the governments and plastic recycling companies. Whereas the European Commission attains a score of 2, the Dutch government attains a 5 and Belgium a 7. Plastic recycling companies believe this is much higher, scoring 8.6 on average. The public side believes large companies do not necessarily want to be involved whereas plastic recycling companies do believe they want to be involved.

The degree to which the complexity of regulation (and regulatory burden) regarding plastic recycling is limiting companies in their capabilities to recycle is ranked on a 1 – 9 scale and has an average of 7.14. The European Commission does not believe that the complexity of regulation and regulatory burden limit companies, considering the score of 2. Both the Dutch and Belgium government do believe that the complexity and regulatory burden is limiting recycling companies, with a score of respectively 8 and 6. Those having to cope with regulation, the plastic recycling companies, also perceive regulation as a limiting factor in their capability to recycle with an average score of 7.6. The

recycling companies in the Netherlands have a score of 7.83, which is close to the score of 7.25 given by Belgium recyclers.

The degree to which participants believe governments are supportive of SME's and innovative companies is respectively 7 for the European Commission, 6 for the Dutch government and 9 for the Belgium government, on a 1 – 9 scale. This is in contrast with the level of support plastic recycling companies experience, 5.7 on average. In the Netherlands the experienced support is lower than average with a score of 4.83 whereas in Belgium the level of support experienced from the government is average.

The statement that innovation is required in order to reach a circular economy is with an average of 8.5 high among the participants. The European Commission, Belgium and the Netherlands scored 9 on a 1 – 9 scale. The plastic recycling companies on average attained a score of 8.3, whereas it should be noted that there is a small difference between plastic recycling companies in the Netherlands and Belgium. Companies active in the Netherlands provided a score of 8, which is close to the Belgium score of 8.75.

Whether or not there are sufficient subsidies available and opportunities to receive investment for developing innovative technologies is, on average, 4.29 on a 1 – 9 scale. Plastic recycling companies perceive that, compared to public bodies, the availability of subsidies and opportunities for investment is lower. The Commission provides a score of 6, so does the Belgium government. The Netherlands provided a score of 4.5 whereas the plastic recycling companies score 3.8 on average.

5. Discussion

This section first applies the research findings to the theoretical framework and the theoretical model. This is followed by the limitations of this study as well as possible directions for further research. Finally, the policy implications of this study are elaborated upon.

5.1 Theoretical explanations

When legislation is proposed by the European Commission, 2050 is used as point of reference, confirming the claim made by Engau and Hoffman (2009) that environmental policy is typically based on long-term considerations and is characterized by a high level of policy uncertainty. Plastic recycling companies have to deal with a two-sided government that is producing contradictory policies, increasing policy uncertainty. This confirms the line of reasoning from Arentsen et al. (2000) that if policies are related to the interests of people, animals, plants and the future generation and when science is playing an important role policy uncertainty is high. This is especially the case with REACH and the maximum degree of contamination. Contradictory policies produced by governments support Rothwell (1980) in his claim that formulating innovation policy is difficult as there is a high degree of uncertainty and a trade-off between different social development goals. Considering that investments are affected by policy uncertainty (Pindyck, 1991; Higgs, 1997; Barradale, 2010), stability in terms of existing laws and regulation is preferred. However, if there are yoyo effects (e.g. tax to landfill waste went from €80 per tonne to €0 to €13) it becomes very difficult for companies to decide on whether or not to invest. Without certainty, the investment attitude of plastic recycling companies has changed. The focus is shifted to short-term economic gains and their attitude to invest has become reluctant, confirming Bernanke's (1983) claim that high uncertainty gives firms an incentive to delay investment. Another source of policy uncertainty relates to the government's position on innovation policies such as the obligation to integrate a certain percentage recycled material in new products. Such legislation will have far reaching implications, considering that it provides demand (e.g. certainty) for recyclate which allows plastic recycling companies to invest in innovative technologies or increasing capacity. This confirms Marcus' (1981) view that innovation policies play an important role, but are not critical. The degree to which innovation is required in order to reach a circular economy for plastic is, based on the questionnaire, high, with an average score of 8.5 on a 1 – 9 scale. However, considering that innovations require investments, which are affected by policy uncertainty (Higgs, 1997; Barradale, 2010), the level of policy uncertainty affects the degree to which companies are able to innovate. The policy uncertainty that is experienced shows that both the European Commission as well as the Belgium and Dutch government perceive less uncertainty, 4.6 on average, compared to degree of uncertainty perceived by plastic recycling companies, 6 on average. Evaluating uncertainty includes the consideration of Sigel's (2010) argument to make a distinction between uncertainty and risk. An

example of an uncertain situation in which the possible outcomes, but not the probabilities of those outcomes are known, is the introduction of REACH and its implications on PVC recycling, confirming the claim made by Engau and Hoffman (2009) that science plays an important role in environmental policy. The threshold value of zinc and lead (based on a maximum PPM that is allowed in the waste stream) is determined based on scientific research and heavily influences the degree to which PVC can, or is allowed to, be recycled. National policies are affected by (a lack of) decision making from the European Commission. As a result of postponed decision making from the Commission, national governments do not know what to anticipate on, leading to uncertainty. Although the direction of the European Commission is clear, the details are very important since an increase from 0.1% to 1% allowed contamination will have a large impact on the degree to which the material is recyclable. Again, the role of science becomes evident in environmental policy, confirming the view of Arentsen et al. (2000). Another cause of policy uncertainty is related to restricting regulations, such as the current definition of waste. As it is unknown what the new definition will be and what implications this will have on plastic recycling as a whole, companies are hesitant with investing, considering that stability in law and regulation is preferred.

The waste directive is one of the oldest European directives. As a result of the decision to opt for a directive, there is a wide variety of plastic waste policies throughout Europe. Although it is acknowledged that it would be beneficial to harmonize policies, changing from a directive to regulation is not considered an option. This confirms Kay's (2005) belief that historical decisions influence and restrict options for future decision making. The consideration to keep working with directives is supporting Kirk's (2007) claim that when having to choose a strategy, it is likely that the option which closely resembles existing practices will be chosen. To change existing and undesired practices, such as landfilling or incineration, regulation and market incentives are governmental instruments to trigger incumbents to change. The current practice, which involves the import of waste for incineration, is hindering recycling and should be changed, however, policy is to a large extent the result of lobbying by incumbents and for them it is not beneficial to innovate radically (e.g. stop landfill and incineration immediately). As the general notion among the participants is that large companies want to be involved in the various phases of policy making, with a score of 7.36 on a 1 – 9 scale, this supports Ashford and Hall's (2011) reasoning that large companies will not set targets they cannot meet. Considering that incumbents change and innovate incrementally in the absence of certainty, imposing stringent regulation is beneficial from a social, economic and political perspective and would trigger innovation. However, considering that the rationale is economic, innovation will only occur if it brings economic benefits. The focus of the government on collection and sorting is the result of historical decisions to target packaging waste, the stability of their focus supports Kay's (2005) view on path

dependency. As a result of the continuous focus on mainly collection, the industry has become used to the subsidies and will oppose any change that challenges the status quo and has financial implications. The perception regarding the degree to which plastic recycling policy has been subject to frequent changes is fragmented, the Commission and the Dutch government do not believe there are frequent changes, scoring respectively 2 and 4 on a 1 – 9 scale. In contrast plastic recycling companies attain a score of 5.4 as they are confronted with practical implications of policies that, in some cases, have not been communicated or anticipated on by policy-makers. This supports Enserink (2013) in his notion that communicating risks and uncertainty is a politicized environment is difficult. Cases in which for green procurement the price remained the decisive factor support Woerdman's claim (2004) that adopting a new approach requires acquisition of information and invest in training/equipment. In turn, in line with the findings of Kirk et al. (2007), it is very difficult to implement a radical new approach when a policy is path dependent, which becomes evident with contradictory policies and the (political) trade-off between green energy and circular economy. Policy-makers are confronted with resource constraints and have to make legislation based on imperfect information, resulting in sub-optimal outcomes. Woerdman's argument (2004) does not hold, considering that the adoption of a new, circular, approach did not result in acquiring sufficient information on possible approaches. What is experienced in the recycling industry is that civil servants have limited knowledge of the practical implications their policy will have, as they maintain a theoretical approach which is not in line with reality. The definition of waste originates from the '70s, a time in which legislation was required to protect the environment from materials being dumped. Since then, the definition has not changed. As a result of the broad definition, it does not allow for the use of recyclate in new products, which supports Kirk et al. (2007). The current definition does not allow for the use of recyclate in new products, which supports Woerdman's view (2004) that acquiring new information and the associated switching costs are avoided by decision-makers. The consolidation of current practices makes it very difficult to change, as the implications are immense. Although Hay (2002; in Kay 2005) argues that policy change is often characterized by moments of crisis, the question remains the level of crisis that is required to change.

For plastic recycling there is a long list of norms and requirements for companies. These norms and requirements are necessary according to OECD (1997) to protect the public health and the environment (e.g. social regulation). However, although companies wish to stop contradictory policies, the government has more societal goals that have to be achieved that make it almost inevitable to have contradictory policies. This confirms Rothwell's (1980) findings that there is little evidence to suggest that regulation stimulates innovation because of the required time and financial investment in order to be in compliance. In Belgium, legislation is aimed at the method (e.g. required licences,

material composition, emissions) instead on the outcome of the recycling process, resulting in accepting Porter's (1991) view that if environmental regulation is focused on outcome instead of method it will result in increased resource efficiency and encourages dynamic change. For companies working with waste, social regulation is a burden since every country is allowed to interpret the European directives in their own way, resulting in different interpretations of an 'accredited waste processor'. This requires companies to register their drivers in all countries they visit, which is practically impossible. This confirms that regulation is harmful to economic competitiveness (Ashfold and Hall, 2011; Rothwell, 1980). The stringent regulation regarding the required licenses to process waste results in increased production costs and gives rise to uncertainty about whether or not their activities are within the legal boundaries, considering the grey zone in which they have to operate as a result of the absence of end-of-waste criteria. This, as a consequence, hinders innovation but supports the classical economic analysis of Ashford and Hall (2011). This is supported by the questionnaire, which shows that the government of the Netherlands and Belgium perceive the degree to which the complexity of regulation regarding plastic recycling is limiting companies in their capabilities to recycle to be respectively 8 and 6. When considering the plastic recycling companies, with a score of 7.6, this belief is shared. However, worth noting is that the European Commission does not perceive regulation to be too complex, considering their score of 2. Companies want to act in line with regulation, however, grey zones are maybe not scary for SME's but they are for big corporates because companies are responsible for what they put on the market. This contradicts Ramanathan's et al. (2010) belief that environmental regulations are considered a market entry barrier for new entrants due to the high regulatory compliance costs. Although this might still be the case, corporates are more risk-averse compared to SME's. The introduction of REACH and the case of PVC recycling in which has been decided the material may contain maximum 0.1% zinc or lead is an example of social regulations, and in support of the OECD (1997), in this case has substantial economic consequences.

5.1.1 Theoretical model

H1: Policy uncertainty has a negative effect on the amount and quality of innovations for plastic recycling technologies

The expected negative effect of policy uncertainty on the amount and quality of innovations for plastic recycling is confirmed. Mostly plastic recycling companies are confronted with the consequences of policy uncertainty which may take many forms. Uncertainty regarding the implications of changing regulation or definitions that are used is affecting the innovative capacity of plastic recyclers. Combined with the absence of pull-effects, which would provide certainty for recyclers in terms of having a steady demand for their product, and the implications this has on investment it shows that has a negative effect. It is interesting to see how policy uncertainty

influences the industry of plastic recycling in multiple ways, which were not anticipated beforehand.

H2: Path dependency has a negative effect on innovations for plastic recycling as it provides little incentive for incremental innovation of the status quo

Path dependency constrains policy makers in their available policy options as a result of historical decisions. Historical decisions, which include investments made in for instance waste incineration facilities are hindering recycling because of the vested interests of incumbents in these facilities. In order for policy to evolve more radically it would require to neglect certain interests, but those are heavily protected by the status quo through, for instance, lobbying. The hypothesis is accepted, on the condition that path dependency is caused by the government and is not the result of the industry protecting their interests.

H3: The disadvantages of environmental regulation exceed the advantages of environmental regulation, resulting in a negative net effect of regulation on innovations for plastic recycling technologies

The effect of environmental regulation on innovations for plastic recycling technologies is negative, so the hypothesis is accepted. Although without regulation recycling would not exist, for innovations the amount and variety of regulations is a limiting factor. The lack of harmonization within Europe in terms of regulations, as well as the old definitions of waste are hindering innovations in plastic recycling through the high costs of compliance and regulatory burden.

H4: Favourable economic conditions, including a growing GDP per capita, a high % GDP spend on R&D, investment opportunities and available subsidies have a positive effect on innovations for plastic recycling

Although it's expected that economic conditions have a positive effect on innovations, this hypothesis is rejected. The consideration to invest is not based on macro-economic conditions such as R&D spending or a growing GDP. Instead, the decision to innovate is based on certainty regarding future market demand as well considerations that relate to the chance that certain waste streams will be illegal to recycle due to new legislation. Subsidies stimulate innovation to a certain extent, however, as subsidies are temporary they do not provide the certainty that companies require before investing in innovative technologies for plastic recycling.

H5: A positive, innovation-oriented entrepreneurial culture has a positive effect on innovations for plastic recycling.

The final hypothesis is rejected based on the analysis which shows that innovations requires certainty and stability in terms of regulation as well as future demand. Even if there is an innovation-oriented entrepreneurial culture, the rationality of those having to innovate remains economic and a without positive economic outlook the incentive to innovate is very limited. Therefore, a positive, innovation-oriented entrepreneurial culture does not have a positive effect on innovations for plastic recycling.

5.2 Limitations and further research

This research has a number of limitations that at the same time provide directions for future research. The most important limitation relates to the degree in which the respondents are representative for the population. The fact is that the plastic recycling industry is fragmented and consists of many subsequent processes that influence the recycling process. Due to the fragmentation, getting a representative sample for the population resulted in a low number of respondents for each particular part of the value chain. This infers questions about the representativeness of the sample and thus the interpretations of the research findings. In a small-N study, which compares two countries, the small-N does not only relate to the number of countries included in the study, but also to the respondents that have participated in this study and represent a certain group. In the case of Belgium policy-makers, only one interview has been conducted. In this situation, the interviewee determines the outcome (as N=1), which implies that a different interviewee might result in a different outcome and therefore poses a limitation to this study. The same applies for the European Commission. For all groups, increasing the number of participants (e.g. sample size) will result in less potential bias. In addition, the response rate of this research is 0.61 (14 out of 23 possible respondents contacted actually participated). Considering that a low response rate results in sample bias, the response rate poses a limitation to this research. Although the reasons for not participating vary, the bias remains evident.

A second limitation is the legitimacy of the causal inferences (e.g. the effect policy uncertainty has on innovations in plastic recycling) that are drawn in this paper. Although the respondents represent different parts of the value chain, they are all categorized as plastic recyclers. Treating the respondents as 1 group (e.g. plastic recyclers) might result in drawing conclusions that are not generalizable to the entire value chain but instead are only experienced in specific parts of the value chain (e.g. collection, sorting, reprocessing). Treating the respondents as a single group results in an overlap between them, considering that in some cases Dutch plastic recycling companies also deal with Belgium legislation and vice versa. This makes it difficult to draw inferences that are specific to a single group.

Another limitation to this study is the fact that the outcome variable (i.e. % landfill, % incinerated and % recycled) is calculated differently in each EU member state. This became evident during this study. This variety between methods of calculation make it very difficult to compare countries based on those numbers and to draw conclusions about the effect of policy uncertainty on innovations in plastic recycling and thus recycling rates. The reliability of the data is questionable, as governments have an incentive to 'play' with the numbers. Also, the complexity of the plastic recycling process increases the risk of causal inferences being influenced by omitted or moderating variables. Finally, as is the case with qualitative research in general, the data generated through interviews is analysed by the researcher and is more easily influenced by preconceptions and personal biases of the researcher.

Based on this study there are a few directions for future research that are recommended. First, to increase the external validity of this research, it could be expanded to other EU countries such as Germany, United Kingdom or France to validate whether the effect is comparable and not limited to the Netherlands and Belgium. Although this study shows that policy uncertainty, path dependency and regulations have a negative effect on innovations for plastic recycling in both the Netherlands and Belgium, from an academic perspective it would be beneficial to increase the number of countries included in the study or to focus on a specific part of the value chain and how policy uncertainty specifically affects that part. It might be the case that policy uncertainty affects plastic waste collection in a different way than it affects the sorting of plastic waste. Having such insights are valuable when implementing changes as they can be targeted specifically instead of being applied generally. In such a study, the amount of participants should be increased compared to this study to avoid groups being represented by a single participant.

Another interesting direction for future research is the adoption of a quantitative approach. Policy uncertainty has a negative effect on the amount and quality of innovations, based on qualitative interpretation of interview data. To measure, statistically, what variables and particularly to what extent this has effect on innovations might provide additional valuable information. It would be interesting to investigate and compare the statistical inferences from the effect of policy uncertainty on plastic waste collectors with the results of plastic separators, or re-processors. Adopting a quantitative approach allows to test for omitted or moderating variables.

The international character of plastic waste problem and plastic recycling calls for an international approach, integrating more (EU) countries in a study on the effects of policy uncertainty on innovations for plastic recycling. As there are currently more local solutions to this global problem, researching solutions on a global scale could benefit plastic recycling significantly. Considering the international character, it is interesting to study the effect, and possibility, of harmonizing the national (plastic)

recycling policies (or at least the way in which the recycling % is calculated) of EU member states, especially since regulation/policies are perceived as a limiting factor for innovations in plastic recycling. Finally, based on the rejected hypothesis that favourable conditions have a positive effect on innovations for plastic recycling making a distinction between different types of innovations (product- or process-innovations) might provide valuable additional insights.

5.3 Policy implications

There are several policy implications that will be addressed based on the results of this study. The implications are meant to stimulate innovations within the plastic recycling industry and to contribute to increasing the recycling rates. In order to stimulate innovation in plastic recycling through regulation, public policy makers should, when drafting new policy or regulation, take into consideration that plastic recycling companies have an economic rationale on which their strategic decisions are made. To stimulate change effectively, economic incentives are a strong instrument for policy makers to bring about change and are one of the requirements for companies to invest (in innovative technologies). Without the certainty of potential economic benefit, companies are more reluctant to invest (Bernanke, 1983). To stimulate recycling, and to demotivate the incineration or landfilling of waste, the effect of demotivation can be increased if there are negative economic implications included such as a high gate fee for incinerating plastics. On the other hand, positive economic implications (through incentives) can also be beneficial to plastic recycling, for instance by lowering the contribution for easy to recycle packaging plastic.

Following Arentsen et al. (2000), environmental policy is characterized with high uncertainty, among others, because of the large role science plays. This is not necessarily bad, however, what policy makers should also consider is that adopting a pure theoretical approach, by neglecting the practical implications, might cause negative externalities for the plastic recycling industry. The discrepancy between the perceived theoretical situation and the situation in reality is causing sub-optimal regulation. Having a deep understanding of the processes involved and the implications of decisions on those processes would be beneficial to the effectiveness of the concerned policy.

What is currently lacking in the market of plastic recyclate are pull effects. The market has been characterized by push effects but in order to increase the amount and quality of innovations in plastic recycling a pull effect has to be created. Pull effects, combined with design-for-recycling, which increases the recyclability of the product significantly, will decrease the uncertainty for the recycling industry because a steady demand means a certain economic outlook which allows for investments. One way for a government to create pull effects is to make it an obligation to integrate a certain percentage, say 20%, of recycled plastic in new products. This would be conditional if companies want

governments as their customer. Taking an exemplary role in buying products with recyclate, policy uncertainty is reduced as a result of the creation of steady demand.

The waste legislation within Europe is very diverse, resulting in high costs of compliance for plastic recycling companies as they have to deal with a wide variety of licenses, requirements and systems. The international character of the plastic recycling industry does not benefit from the different requirements EU member states have on an individual level. Harmonizing the plastic waste policy within Europe would bring considerable benefits, as the costs of compliance with regulation will decrease. While doing so, a holistic approach should be adopted in which the entire value chain is considered and focussed on achieving circularity. The first step would be to change the definition of waste, which originates from the '70s, to then continue with harmonizing the method of calculating recycling rates as well as the required licenses for transport and/or processing of waste.

The proposed policy implications include radical change and re-thinking of existing practices. In order to achieve the change that a circular economy for plastic requires, incremental progress and innovation will not suffice.

6. Conclusion

This study aimed to make a contribution to public administration research by providing a better understanding of the relationship between policy uncertainty and innovations in plastic recycling technologies and whether or not policy uncertainty is a limiting factor in reaching a circular economy for plastic. The research question of this study is: *How does policy uncertainty affects innovations in plastic recycling and is policy uncertainty a limiting factor for achieving circular economy for plastic?* This study focused on the European Commission, the national governments of the Netherlands and Belgium and plastic recycling companies in both the Netherlands and Belgium. Through semi-structured interviews, including a questionnaire, perceptions and experiences are obtained that relate to the concepts of policy uncertainty, path dependency, regulatory burden and entrepreneurial culture and how these concepts affect innovations in plastic recycling.

In this research it is expected that policy uncertainty has a negative effect on innovations in plastic recycling. This is based on research, among others, by Barradale (2010), Carruth et al. (2000), Kang et al. (2014) and Bhattacharya (2013) who provide evidence that policy uncertainty gives firms an incentive to delay investment and that is has adverse effects on innovations. This study shows that the European Commission adopted 2050 as a reference point to base their long-term strategy on, which has resulted in an uncertain situation for both governments and recycling companies. The policy uncertainty is experienced in several ways. First of all, governments implement contradictory policies as a result of having to choose between the many societal goals, for instance, policy beneficial for the circular economy is not beneficial for the production of green energy which involves the incineration of materials that could have been used in a circular economy to create new products. In addition, the stability of policy is debatable and has resulted in yoyo-effects for waste disposal fees that make it difficult for companies to decide whether or not to invest since their business models are heavily influenced by the waste disposal fees. The recycling companies' change in investment attitude becomes clear when considering that the focus has changed to short-term economic gains as a result of the uncertainty regarding the continuity of their business. Uncertainty about future decisions also influence innovations in plastic recycling. The definition of waste, originating from the 70's, ought to change, however, the new definition will have far reaching implications, just as the current definition has. Not knowing how it will change results in companies being reluctant to invest. A recurring suggestion to support innovations in plastic recycling is that the government's should make it an obligation to integrate recycled plastic into new products (e.g. create pull effects). Such an obligation would create a steady demand for recyclate and decrease the policy uncertainty that is experienced by the plastic recycling industry. To achieve circularity for plastic, innovation is required and this study's findings show that policy uncertainty is perceived as a limitation for plastic recycling companies to

invest and innovate. However, it should be noted that policy uncertainty is not the only limiting factor for achieving a circular economy for plastic.

For path dependency it is expected to have a negative effect on innovations for plastic recycling as it provides little incentive to innovate. This is based on studies by Kay (2005) and Kirk et al. (2007) who provide strong evidence that policy decisions, made over time, influence and restrict options for future decision making. The existing path is more likely to be continued than a new one taken – even if the new path would deliver better results. The influence of path dependency on plastic recycling policy is clear. The historical decision of the Commission to work with directives heavily influenced the policy landscape of today. As a result of this decision, plastic recycling policies throughout Europe are fragmented and are characterized with a high variety between EU member states. The import of waste, which is 'required' to compensate for overcapacity of incineration facilities, is also the result of historical decisions. The incineration overcapacity is not contributing to innovations in plastic recycling, considering that it provides a cheap(er) alternative to recycling and especially because the incineration price for municipalities has decreased with 50% since 2011. The focus of the government on the collection of plastic waste is the result of the decision to target plastic packaging waste. The approach resulted in subsidizing the collection and sorting of plastic packaging waste which has made the industry dependent on subsidies, making it difficult to change the status quo. A final effect of path dependency on innovations is within green procurement. The decision for green procurement should include environmental considerations but in reality price remains the decisive factor.

In this study it is expected that the net effect of regulation is negative. This perception is based on the findings of Rothwell (1980), Ashford and Hall (2011) and Ramanathan et al. (2010) that regulation does not stimulate innovation and is considered to be harmful to economic competitiveness through the induced regulatory compliance costs. This study shows that without regulation, plastic recycling would not exist, but at the same time proves to be a limiting factor considering that regulation can have many objectives, amongst others, to protect the environment and health of citizens. Regulation can be contradictory and in the absence of end-of-waste criteria results in a grey zone for plastic recycling companies. In this grey zone, there is a lot of uncertainty regarding the regulatory obligations recycling companies have. Companies want to be in compliance with existing regulation, but the uncertainty regarding the obligations is especially scary for big corporates who are more concerned with their responsibility for products they put on the market. These grey zones relate to the question whether or not a material is classified as waste or as resource. The current definition of waste does not allow for waste to be classified as a material, which might be the case more often than not. As has been mentioned, the fragmented recycling policies throughout Europe resulted in companies having to comply with a multiplicity of regulations. The required licenses for transporting, processing or using

‘waste’ (or resource?) are not limited to a single EU license, instead each EU member state requires an individual license. This increases the experienced regulatory burden significantly and does not contribute to innovations in plastic recycling. Harmonizing policies and regulation on a European level will benefit plastic recycling as the regulatory compliance will decrease, especially considering that the problem of plastic waste is not at all limited to the borders of a country.

7. Bibliography

Arentsen, M., Bressers, H., & O' Toole, L. (2000). Institutional and Policy Responses to Uncertainty in Environmental Policy: A Comparison of Dutch and U.S. Styles. *Policy Studies Journal, 28*(3), 597 - 611.

Ashford, N. A., & Hall, R. P. (2011). The importance of regulation-induced innovation for sustainable development. *Sustainability*, *3*(1), 270–292.

Baker, S., Bloom, N., & Davis, S. (2016). Measuring Economic Policy Uncertainty. *The Quarterly Journal of Economics,131*(4), 1593 - 1636.

Barradale, M. (2010). Impact of public policy uncertainty on renewable energy investment: Wind power and the production tax credit. *Energy Policy, 38*(12), 7698-7709.

Ben-Haim, Y., Osteen, C.D., & Moffitt, L.J. (2013). Policy dilemma of innovation: An info-gap approach. *Ecological Economics, 85*, 130 - 138.

Bernanke, B. (1983). Irreversibility, Uncertainty, and Cyclical Investment. *The Quarterly Journal of Economics, 98* (1), 85 - 106.

Bhattacharya, U., Hsu, P.-H., Tian, X., & Xu, Y. (2013). What Affects Innovation More: Policy or Policy Uncertainty? *SSRN Electronic Journal*.

Brendle, E. (2017) "An analytical view on recycled polymers" Intertek presentation, Cologne.

Business Insider (2016). *Hollande complains of slow EU decision making.* Retrieved April 3, 2017 from: http://www.businessinsider.com/ap-the-latest-hollande-complains-of-slow-eu-decision-making-2016-4?international=true&r=US&IR=T

Carruth, A., Dickerson, A., & Henley, A. (2000). What do We Know About Investment Under Uncertainty? *Journal of Economic Surveys, 14*(2), 119-154.

Christensen, C., Raynor, M., & McDonald, R. (2015). 'What Is Disruptive Innovation?' Retrieved April 28, 2017, from:
https://hbr.org/2015/12/what-is-disruptive-innovation

Christensen, C. (1997) *The innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Bosten, MA: Harvard Business School Press.

Collier, D. (1993), 'The Comparative Method', in A.W. Finifter (ed.), *Political Science: The State of Discipline II*, Washington D.C: The American Political Science Association, pp. 105 – 119

Cornell University, INSEAD, and WIPO (2016): *The Global Innovation Index 2016: Winning with Global Innovation,* Ithaca, Fontainebleau, and Geneva.

Daiku, H., Inoue, T., Tsukahara, M., Maehata, H., & Kakeda, K. (2001). Electrostatic separation technology for waste plastics-development of a high-purity type separator for plastics. *Proceedings Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing*, 562–565.

Ellen MacArthur Foundation & McKinsey (2016). The New Plastics Economy.

Engau, C. and Hoffmann, V.H. (2009). Effects of regulatory uncertainty on corporate strategy—an analysis of firms' responses to uncertainty about post-Kyoto policy. *Environmental Science and Policy, 12*(7), 766-777.

Enserink, B. Kwakkel, J.H. & Veenman, S. (2013). Coping with uncertainty in climate policy making: (Mis)understanding scenario studies. *Futures, 53*, 1-12.

European Commission (2017a). 'Circular Economy'. Retrieved April 2, 2017 from http://ec.europa.eu/environment/circular-economy/index_en.htm

European Commission (2017b). 'Waste Electrical and Electronic Equipment (WEEE)'. Retrieved April 2, 2017 from http://ec.europa.eu/environment/waste/weee/index_en.htm

European Commission. (2017c). 'Plastic waste - Strategy and background'. Retrieved April 3 2017, from http://ec.europa.eu/environment/waste/plastic_waste.htm

European Parliament (2008). 'Directive 2008/98/EC of the European Parliament and of the council'. Retrieved April 5, 2017 from http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0098&from=EN

European Union (2017). 'Regulations, directives and other acts'. Retrieved April 5, 2017 from https://europa.eu/european-union/eu-law/legal-acts_en

Eurostat (2017). 'Recycling rates for packaging waste'. Retrieved April 30, 2017 from http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=ten00063&language=en

Flick, U. (2014), *An introduction to qualitative research.* Sage Publications Ltd.

Furman, J.L., Porter, M.E., Stern, S. (2002). 'The determinants of national innovative capacity', *Research Policy*, 31, pp. 899 – 933.

Georghiou, L., & Secretariat, E. C. (Ed.) (2006). Innovation Policies for Europe: the Missing Demand-Side. In *Globalisation Challenges for Europe* (18 ed., pp. 173-194). Helsinki: Prime Ministers Office Publications Finland.

Global Entrepreneurship Monitor. *Global report 2016-2017*.

Haverland, M. (2000). National Adaptation to European Integration: The Importance of Institutional Veto Points, *Journal of Public Policy*, 20, (1), p. 83 – 103.

Higgs, R. (1997). Regime Uncertainty: Why the Great Depression Lasted So Long and Why Prosperity Resumed after the War. *The Independent Review, 1*(4), 561-590.

Hu, B., Giacometti, L., Maio, F. D. I., & Rem, P. (2011). Recycling of WEEE by Magnetic Density Separation, 278–282.

Kang, W., Lee, K., & Ratti, R. (2014). Economic policy uncertainty and firm-level investment. *Journal of Macroeconomics, 39*, 42.

Kay, A. (2005). A Critique of the Use of Path Dependency in Policy Studies, *Public Administration*, 83, 3, 553-571.

Kirk, E., Reeves, A., & Blackstock, K. (2007). Path Dependency and the Implementation of Environmental Regulation. *Environment and Planning C: Government and Policy, 25*(2), 250-268.

Krueger, A. (1974). The political economy of the rent-seeking society. *The American Economic Review, 64*(3), 291-303.

Kuhlmann, S. (2001). Future governance of innovation policy in Europe — three scenarios. *Research Policy, 30*(6), 953-976.

Landman, T. (2008), *Issues and Methods in comparative politics*. Taylor & Francis ltd.

Let's Recycle (2017). 'Waste industry to lobby over EU recycling definition', Retrieved April 4, 2017 on: http://www.letsrecycle.com/news/latest-news/waste-industry-to-lobby-over-eu-recycling-definition/

Marcus, A.A. (1981). Policy Uncertainty and Technological Innovation. *Academy of Management Review*, *6*(3), 443–448.

McKinsey (2016). 'Rethinking the future of plastics'. Retrieved April 2, 2017 from http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/rethinking-the-future-of-plastics

Meijer, I.S.M. (2008), *Uncertainty and entrepreneurial action. The role of uncertainty in the development of emerging energy technologies*. Utrecht University Repository.

OECD (2015a). 'Disruptive innovations and competition'. Retrieved April 3, 2017 from http://www.oecd.org/daf/competition/disruptive-innovations-and-competition.htm

OECD (2015b), *The innovation imperative: contributing to productivity, Growth and Well-being*, OECD Publishing, Paris.

OECD (2014), 'SME Policy Index Methodology'. Retrieved May 24, 2017 from https://www.oecd.org/globalrelations/SME%20Policy%20Index%20Methodology_Concept%20Note.pdf

OECD (2010), *Innovative SMEs and Entrepreneurship for Job Creation and Growth*, Paris: OECD Publishing.

OECD (1997), *The OECD Report on Regulatory Reform: Synthesis*, Paris: OECD Publishing.

Paraskevopoulou, E. (2012). Non-technological regulatory effects: Implications for innovation and innovation policy. *Research Policy*, *41*(6), 1058–1071.

Pindyck, R. (1991). Irreversibility, uncertainty, and investment. *Journal of Economic Literature, 29*(3), 1110-1148.

Plastics Europe (2016a). 'Plastics – The facts 2016'. Retrieved March 31, 2017 from http://www.plasticseurope.org/Document/plastics---the-facts-2016-15787.aspx?FolID=2

Plastics Europe (2017b). 'Waste collection'. Retrieved April 2, 2017 from http://www.plasticseurope.org/plastics-sustainability-14017/zero-plastics-to-landfill/waste-collection.aspx

Plastics Europe (2017c). 'Waste pre-treatment and sorting'. Retrieved April 2, 2017 from http://www.plasticseurope.org/plastics-sustainability-14017/zero-plastics-to-landfill/waste-pre-treatment-and-sorting.aspx

Plastic Recyclers (2017). 'Plastic waste management'. Retrieved April 2, 2017 from http://www.plasticsrecyclers.eu/plastics-waste-management

Poel van de, I. (2000). On the Role of Outsiders in Technical Development. *Technology Analysis & Strategic Management,* 12(3), 383-397.

Porter, M., 1991. America's green strategy. Scientific American 264 (4), 168.

Puller, S. L. (2006). The strategic use of innovation to influence regulatory standards. *Journal of Environmental Economics and Management*, *52*(3), 690–706.

Raadschelders, J. (1998). Evolution, institutional analysis and path dependency: An administrative-history perspective on fashionable approaches and concepts. *International Review of Administrative Sciences, 64*(4), 565-582.

Ramanathan, R., Black, A., Nath, P., & Muyldermans, L. (2010). Impact of environmental regulations on innovation and performance in the UK industrial sector. *Management Decision*, *48*(10), 1493–1513.

Recycling Waste World (2015). '*Riding the wave of waste M&A's*', Retrieved April 16, 2017 on: http://www.recyclingwasteworld.co.uk/in-depth-article/riding-the-wave-of-waste-mas-1/111558/

Rothwell, R. (1980). The Impact of Regulation on Innovation: Some U.S. Data, *Technological forecasting and social change*, 17, pp. 7 – 34.

Sigel, K., Klauer, B. & Pahl-Wostl, C. (2010). Conceptualising uncertainty in environmental decision-making: The example of the EU water framework directive. *Ecological Economics, 69*(3), 502-510.

Tolinski, M. (2009). 'Additives for polyolefins' PDL Handbook Series, William Andrew Applied Science Publishers, Elsevier.

Thelen, K. (1999). Historical institutionalism in comparative politics. *Annual Review of Political Science,2*(1), 369-404.

Toshkov D. (2015), *Research Design in Political Science*. Palgrave Macmillan.

Umincorp (2017). 'The principle'. Retrieved April 4, 2017 from http://www.umincorp.com/technology

United nations (2004). Plastic Waste causes $13 billion in annual damage to marine ecosystems, says UN agency. Retrieved April 3, 2017 from http://www.un.org/apps/news/story.asp?NewsID=48113#.WOedldKGPDc

Verschuren, P., & Doorewaard, H. (2007). *Het ontwerpen van een onderzoek*. Den Haag: LEMMA.

Woerdman, E., & Albrecht, Johan. (2004). Path-dependent climate policy: The history and future of emissions trading in Europe. *European Environment, 14*(5), 261-275.

World Bank (2017). 'New Business Density (new registrations per 1000 people ages 15-64)'. Retrieved April 30, 2017 from http://data.worldbank.org/indicator/IC.BUS.NDNS.ZS?locations=BE-NL

World Economic Forum (2016). *The Global Competitiveness Report 2016-2017*. Geneva: World Economic Forum.

Yu, D., Hang, C.C. (2010). A Reflective Review of Disruptive Innovation Theory, *International Journal of Management Reviews*, 12, (4), p. 435 – 452.

8. Appendices

8.1 Appendix 1: Interview questions

- What is your function and could you describe a typical day of work?
- How would you define plastic recycling?
- What is your experience with recycling plastic? Any specific part of the value chain?

- How would you describe the policy of plastic recycling over the last 5-10 years? (clear or not?)
- What are your expectations of future policy regarding plastic waste recycling?
- What is, in your opinion, the rationale of policy makers when considering policy options?
- What should be, in your opinion, the rationale of policy makers when considering policy options?

- How would you describe the uncertainty that is related to (governmental) policy?
- In your opinion, how does (policy) uncertainty affects the daily business and long-term strategy of your organization?
- How do you deal with this uncertainty?
- Do you have an example of a policy that was changed drastically and what were the implications?

- What is, in your opinion, required for an innovative plastic recycling technology in terms of economic conditions to become successful? Which factors contribute and which factors don't contribute?
- Could you describe your experience with starting the development of an innovative technology?

- How would you describe your experience when dealing with governmental regulations? I.e. compliance burden
- Which factors do you considered to be limiting for achieving circularity for plastics?

- What is your opinion on the contribution of SME's to plastic recycling?
- Is the government supportive, in your opinion, towards innovative SME's?
- How, in your opinion, does having a lively start-up community that is supported by the government through policy, tax benefits and has access to finance benefit the recycling rates of a country?

- What is, in your opinion, the key solution to reach true circularity for plastic?

8.2 Appendix 2: Questionnaire

Indicate the extent to which you agree with the following statements

1. Public policy regulating plastic waste recycling is uncertain

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

2. The policy regarding plastic recycling is subject to frequent changes

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

3. Large companies want to be involved in the various phases of policy making

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

4. Large companies are involved in the various phases of policy making as they benefit from the status quo

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

5. The complexity of regulation (and regulatory burden) regarding plastic recycling is limiting companies in their capabilities to recycle.

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

6. The government is supportive of SME's and innovative companies

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

7. Innovation is necessary in order to reach a circular economy for plastic

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

8. There are sufficient subsidies available and opportunities to receive investment for the development of innovative technologies

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

9. Without available subsidies, investing in innovative plastic recycling technologies would not bring economic benefits

Completely disagree ○ ○ ○ ○ ○ ○ ○ ○ ○ Completely agree

8.3 Appendix 3: Questionnaire results

	Average	EC	NL government	BE government	Recyclers	NL recyclers	BE recyclers
	N=14	N=1	N=2	N=1	N=10	N=6	N=4
Public policy regarding plastic waste recycling is uncertain	5.29	2	4.5	3	6	6.17	6
The policy regarding plastic recycling is subject to frequent changes	5.14	2	4	8	5.4	5.17	5.75
Large companies want to be involved in the various phases of policy making	7.36	4	5	7	8.6	8.67	8.5
Large companies are involved in the various phases of policy making as they benefit from the status quo	5.64	4	3.5	7	6.5	7.33	5.25
The complexity of regulation (and regulatory burden) regarding plastic recycling is limiting companies in their capabilities to recycle	7.14	2	8	6	7.6	7.83	7.25
The government is supportive of SME's and innovative companies	6.07	7	6	9	5.7	4.83	7
Innovation is necessary in order to reach a circular economy for plastic	7.86	9	9	9	8.3	8	8.75
There are sufficient subsidies available and opportunities to receive investment for the development of innovative technologies	4.29	6	4.5	6	3.8	4.67	2.5
Without available subsidies, investing in innovative plastic recycling technologies would not bring economic benefits	6	6	5	5	6.4	6.33	6.5