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What a waste – a critical appraisal of Germany's plastic waste trade 2000 – 2018

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Abstract: In recent years, the global problem of plastic waste has received increasing attention. Plastic waste is frequently traded good and is often exported to countries which mismanage large proportions of their waste. By investigating Germany's imports and exports to a selection of countries this study finds that the German recycling system has flaws in the area of plastic waste. Due to the fact that plastic waste trade is not sufficiently regulated, Germany is exporting higher quantities of plastic waste than it is importing. Under consideration of recent advancements in the field of sustainability transitions, this study finds that the policy interventions are needed to face future challenges of increasing recycling quotas in Germany. Policy frameworks that introduce creation measures that foster innovation as well as destruction measures that withdraw support from existing regimes can serve as guidance for policy makers and future research.

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List of Abbreviations

GL Index: Grubel Lloyd Index

MLP: Multi Level Perspective

PE-LD: Polyethene low density

PE-HD: Polyethene high density

PP: Polypropylene

PET: Polyethylenterephthalat

PS: Polystyrol

PVC: Polyvinyl chloride

SNM: Strategic Niche Management

TIS: Technological Innovation Systems

TM: Transition Management

1 Introduction

In the past years, the global plastic problem has received extensive media coverage. Especially the report "The New Plastics Economy" by the EllenMacArthur foundation (2016) which has addressed this issue by presenting data which indicates that, by the continued action of the status quo, the ratio of fish and plastic in the sea will be 1:1 by 2050 (Ellen Mac Arthur Foundation, 2016). Furthermore, in research the plastic problem has led to an ongoing debate about the developments of plastic and plastic waste. One study by Geyer et al. (2017) found that plastic is one of the fastest growing production goods with an annual growth rate of around 8% between 1980 and 2015. In their study, they investigated how plastic production developed in the past and developed trends for the generation of plastic waste worldwide and set it into relation with the development of the recycling rate for plastics. In their conclusion, they presented that if the development of 0.7% annual growth rate continues for the share of recycling, the world would reach a recycling rate of 44% for plastic waste only by 2050 (Geyer, Jambeck & Law, 2017).

Considering this brief introduction to the topic of plastic production and ultimately plastic waste, it becomes clear that the challenge of growing consumption and increased globalisation of production creates a global plastic waste problem. Some countries, especially European countries, are in the process of developing closed circular systems with the aim to increase recycling of plastic waste. This is also due to the new targets of the European Union to make all produced plastics recyclable by 2030. In the European Union's vision for a "new plastics economy" within the European Union, the reuse, recycling and repair of plastic products lay at the core of the targets. Synergy effects of the policy direction are the reduction of greenhouse gasses, thus less dependency on fossil fuels and the creation of employment within the EU (European Commission, 2018b).

Considering the first paragraph, it is worth mentioning that the vast majority of plastic waste in the seas originates from developing countries, mainly from rivers in South East Asia (Jambeck et al., 2015). These countries often have insufficient waste management systems. A recent study by Greenpeace (2018), shed light towards the main issue this paper will focus on, German plastic waste in these countries. In their report, Greenpeace has found that Germany is one of the four most significant contributors to plastic waste of illegal landfills in Malaysia (The

Recycling Myth, 2019). Thus, we arrive at a few fundamental questions; How does German waste end up in Malaysia? Moreover, why does it end up in Malaysia? This study will aim to address these issues. Thus, the scope of this study proceeds to the main research questions:

How did imports and exports of plastic waste in Germany develop since the year 2000?

What policy mechanisms are in place in Germany to prevent the export of plastic waste to countries where plastic waste is mismanaged?

In order to understand these developments, a closer look at waste related policy and trade data is required. Thus, this paper aims to explore the mechanism of policy mixes in combination with sustainability transitions. Since around 2004, sustainability transitions have received increasing attention from the academic community. In the year 2004, the field had roughly 100 citations per year and grew to over 2000 per year in 2011 (Markard, Raven & Truffer, 2012). However, the vast majority of these papers deal with transitions in the energy sector, followed by new developments in transportation (Markard, Raven & Truffer, 2012). Plastic waste and waste policy have been somewhat of a "blind spot" in the field of policy mixes for sustainability transitions.

The current structure of plastic flows from production to waste shows some considerable flaws that further stress the motivation for this thesis. From 19,8 million tonnes of produced plastic, only 8,3 million tonnes ended up in waste-to-energy, landfill or re-use facilities. One reason for this may be that the dual-systems, which are responsible for the collection and sorting of post-consumer plastic waste, control where the waste flows (Örtl, 2019). These dual systems export plastic waste for recycling purposes. However, to the public, it often remains unclear where the plastic waste ends up. The German government has waste management policies in place that aim to control and optimise the collection and recycling of plastic waste. Since 2019, a new packaging law is in place that includes increased producer responsibility. In the future producers of plastic packaging will have to register what they produce, thus, increasing transparency (Bundesgesetzblatt Teil I, 2017).

This is where this paper shall fill in. This paper does not aim to provide a full-scale analysis of Germany's policy for plastic waste; this is clearly beyond the scope and limitations of a rather small thesis. It is instead a first step in the direction of policy mix analysis for sustainability transitions related to plastic waste related policy. By building upon a novel framework introduced by Kivimaa et al. (2016), the focus shall lie on the destabilising policy mechanism

and how these influences the exports of plastic waste. In their framework, Kivimaa et al. (2016) introduce a novel approach to the analysis of innovation policy. They focus not only on creation mechanism and policies that aim to foster innovation, as previous scholars have, but also on destructive policy mechanism. Destructive policy mechanism aim to withdraw support of existing regimes to support innovations to overcome the entry barriers to the marketplace. Special attention in this study is given to the destructive Dimension 1. This dimension includes restrictive policies such as import/export restrictions (Kivimaa & Kern, 2016). As the research questions are concerned with the developments of imports and exports to countries where waste is often mismanaged, the analysis will include Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey. These countries have been found to mismanage large proportions of waste (Jambeck et al., 2015). Thus, it becomes of interest how much plastic waste is exported to these countries from Germany and what policies are in place to control this flow of imports and exports.

The structure of this thesis is as follows: The first section includes a description of the plastic regime in Germany and what notable policies have been passed that may influence the recycling and trade of plastic waste. Policy developments that influence Germany can be found on a national level, but also on the EU level and from external countries like China, the section will present notable advancements in these areas as well. The section also discusses previous research in the field of innovation policy and sustainability transitions. Chapter three is concerned with the data that is used to analyse the flows of imports and exports of German plastic waste. Chapter four will describe the method applied to analyse the relationship between imports and exports. The final two chapters are concerned with the analysis of the data and the relation to the literature and concluding remarks, including limitations and directions for future research.

2 Literature Review

The following literature review will provide an overview of past research and provide insights into the structure of the plastic waste regime in Germany. The first section will present the reader with the market structure in Germany, including notable recent developments in policy both in Germany and from external parties. Secondly, the literature review will go in depth in the field of innovation policy and sustainability transitions. Especially the field of sustainability transitions has received increasing attention by scholars in the past decade and offers different approaches on how to design a policy to foster sustainability transitions.

2.1 Plastic Life stream – where does it come from and where does it end up?

In the following section, the current plastic regime/market structure is described briefly. The below-illustrated market structure is a simplified version of where the plastic comes from, and where it ends up. In 2013, Germany produced 19,8 million tonnes of plastic. This production was largely comprised of the following plastics:

- Polyethene (PE-LD und PE-HD),
- Polypropylene (PP),
- Polyethylenterephthalat (PET),
- Polystyrol (PS),
- Polyvinyl chloride (PVC)

However, the illustrated product flow does not differentiate between the different types of plastic. Despite this, it becomes evident to the reader that there is a considerable gap between

the 19,8 million tonnes produced and the roughly 8,3 million tonnes which end up in landfill, waste-to-energy and recycling facilities (Örtl, 2019).

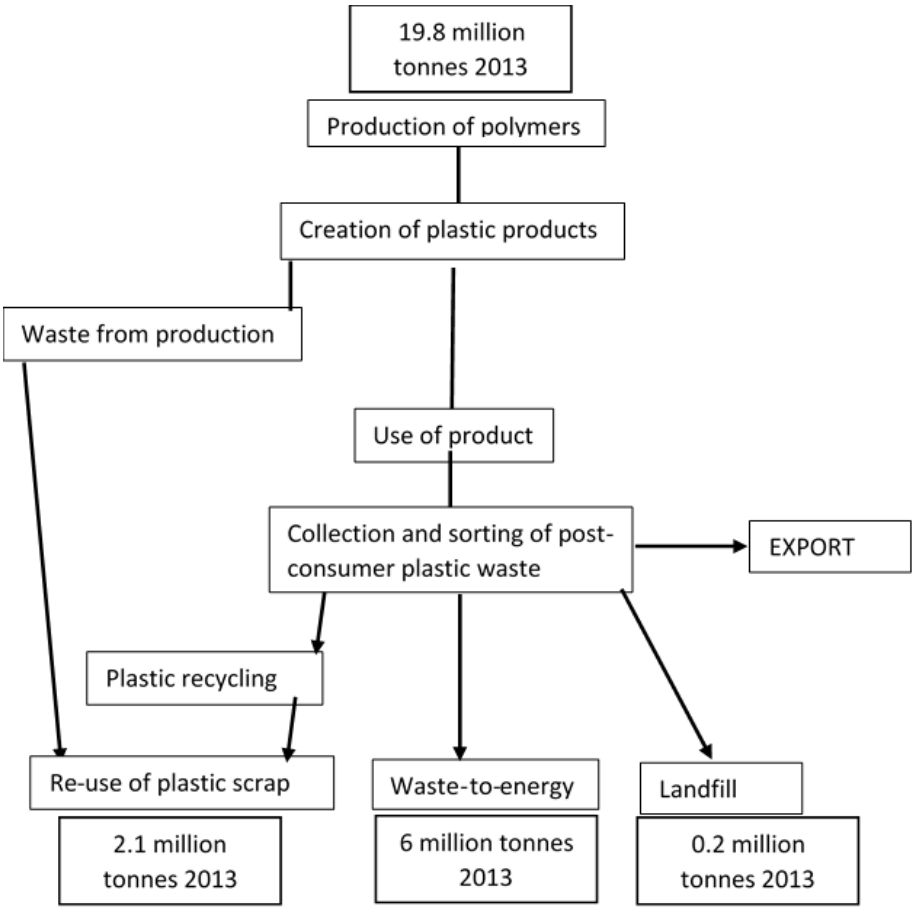

Figure 1 Simplified flow of plastic from production to end-of-life/recycling

(simplified own creation based on (Örtl, 2019))

In the above process, the so-called "dual systems" in Germany play a significant role. They are private companies, and in most cases responsible for the collection and sorting of household waste. Thus, they are in control of the waste and decide which stream the collected waste shall follow. This is, of course, highly dependent on the quality of the collected waste. Household plastic waste is often impossible to recycle. Nevertheless, the collection system for PET bottles in Germany prides itself with a recycling rate of 97,2% in 2013, which is due to the €0.25 return reward per bottle, which is paid extra when the consumer buys the PET bottle (Örtl, 2019).

A crucial point in the potential recycling of plastic waste is the level of quality producers require in their manufacturing process. In Germany, a purity rate between 90% and 96% is required

from secondary raw materials derived from plastic waste recycling. This can only be reached by complex cleaning and purification processes in mechanical recycling through sorting and cleaning. An example at this stage could be PE post-consumer plastic waste. Even with the sophisticated recycling processes in Germany, only 72% of the PE waste which arrives in a facility that creates recyclates (the raw material which can be used in the production process) can be used i.e. even the recycling process itself creates plastic waste, in this case 28% which cannot be used anymore. In the case of PP the number is even lower with only 70% creating recyclates (Örtl, 2019).

Furthermore, a considerable amount of plastic waste which is collected by the dual systems is exported for recycling purposes. From 382,000 tonnes PE-HD (high density PE) waste, 277,000 tonnes went into export for recycling purposes. For PE-ND (low density PE), of 451,000 tonnes of waste only 330,000 tonnes went into export for recycling.

As illustrated in these examples and the plastic life stream, a considerable amount of German plastic waste is recycled abroad. However, as the table below indicates, in 2013 the actual recycling i.e. the reuse of the product, is rather low in Germany as well as abroad.

Table 1: Example Recycling rates of different types of German plastic in Germany and abroad 2013

Secondary-raw material	Mechanical recycling in Germany and abroad	Recycling in facilities in Germany and abroad	Waste-to-energy in Germany
PE -HD	23%	35%	63%
PE - LD	21%	21%	77%
PP	12%	24%	74%
PET	74%	67%	32%
PS	22%	28%	70%
PVC	8%	29%	71%

Germany's dual systems recycling approach has received much criticism from relevant recycling bodies. As countries like China have received large shares of German plastic waste, the recycling companies in Germany often lack supply. Further, the recyclers stress that the dual systems can only export the plastic waste due to economic reasons like lower labour costs and not for ecological reasons of, for example, higher recycling rates (Lindner & Hoffmann, 2015).

2.2 Policy concerning plastic waste in Germany

The foundation for the treatment of plastic waste in Germany dates back to 1991 when the first packaging law was passed. Since then, the above-described regime around plastic and plastic waste has evolved. Collection and recycling rates not only for plastic but also for other waste like paper packaging increased during the years especially since the market opened for dual systems around the year 2000 (Rothgang, Dehio & Janßen-Timmen, 2017). Since the 1st of January 2019, a new packaging law has been in place. It replaces the old packaging directive from 1998 and covers new areas like the increased responsibility of producers of plastic packaging. Thus, producers of plastic packaging must register how much plastic packaging they use, how much is put on the market and the period in which their product is in touch with plastic packaging. The aim is to get more insights into how much plastic is produced, what kind of plastic is on the market and for what reasons (Bundesgesetzblatt Teil I, 2017).

Furthermore, recycling targets have increased considerably. For plastic waste the "old" target was 36%, but from 2019 onwards this has been raised to 58,5%, and from 2022 it shall be 63%. This puts considerable pressure on producers and recycling facilities as they need to obey the new recycling targets (Bundesgesetzblatt Teil I, 2017).

However, as this study is mainly concerned with the trade of plastic waste, it has to be noted that the packaging law does not cover any restrictions on the trade with plastic waste. Trade of waste is regulated by the "Basel Agreement" which serves as the foundation for the order "1013/2006/EG". In general, the trade of waste is allowed. However, most waste products are only covered in terms of being "notification goods" thus, it needs to be reported if they are traded. However, they are not restricted or banned for trade (besides hazardous materials) (Lehmphul, 2014). In particular, plastic waste is traded in considerable amounts as it is not

restricted. In 2009, 73,7% of German plastic waste was exported for recycling purposes (Lindner & Hoffmann, 2015).

For some time now, countries have made efforts to reduce or even ban the export of waste for recycling. In 2012 Italy planned to restrict the exports of "secondary raw materials," i.e. waste. However, due to pressure from industry groups and the European Commission, they dropped their plans (Lindner & Hoffmann, 2015). As the issue of plastic waste is receiving more attention in recent years, on the 10th of May 2019 180 countries have agreed to regulate the exports of plastic and increase transparency (Basel Convention, 2019).

As of this year, the new packaging law in Germany became effective, and most recently, the Basel Convention has led to an agreement which will regulate plastic waste trade. However, also on the EU level policies are targeting plastic waste, especially through the angle of reducing plastic waste. In 2018, the EU published a strategy with the aim of reducing waste and increasing recycling. New rules which will be applied throughout the EU in the coming years include a ban of selected single-use plastic products, reduction of consumption from single-use food containers, extended producer responsibility schemes and increased collection rates (European Commission, 2019b). Furthermore, the EU has agreed on a monitoring framework which includes specific measures to tackle the waste problem in the EU and abroad. The circular framework includes production and consumption, waste management, secondary raw materials and competitiveness/innovation. The framework aims to create and foster innovation and jobs to minimise waste and make all plastic-based products recyclable by 2030 (European Commission, 2018a). However, if we relate this to previous studies in the field of innovation systems, we find that the point raised by Kivimaa et al. (2016), about the lack of destructive policies in innovation policy, becomes evident once more (Kivimaa & Kern, 2016). The monitoring framework includes plans for investments and the creation of new processes through research. However, trade policy is only mentioned briefly, and it does not become evident what goals are meant to be achieved through it. The ban of single use products is the only clear destructive policy measure.

2.3 Asia – Waste Management and China's green fence

Waste management and policies considering waste in Asia have received growing attention in the past years. As China was historically the largest importer of plastic waste but had no regulations or sufficient waste management, the environmental impact of plastic waste got out of hand. In provinces like Hebei and Shandong, "recycling villages" grew, in which low-income households recycled plastic waste themselves without any concern for health and environment. This lead to polluted rivers and dangerous levels of pollution in the air as plastic waste was often burned (Lindner & Hoffmann, 2015).

The Chinese government introduced a new set of policies called "the green fence" to tackle the environmental problems caused by plastic waste and waste imports. As China has imported 45% of the cumulative plastic waste since 1992, the government banned the imports of all household plastic waste and created clear roles for recycling. Thus, PE, PS, PVC, PET, and others (for example, PP), as well as bales of PET are restricted from being imported (Brooks, Wang & Jambeck, 2018). This policy action somewhat relates to the "destruction" Dimensions of Kivimaa et al. (2015). However, the difference is that it is external policies that put pressure on the market, not German or European policies. The EU-28 would be the single largest exporter of plastic waste if considered "one" with Germany as the leading exporter. The Chinese import ban will influence the EU and especially Germany heavily as around 111 million metric tonnes of plastic waste will have to find a new "home" until 2030 (Brooks, Wang & Jambeck, 2018).

Jambeck et al. (2015) stress this issue of misplaced waste, the countries which import most of the plastic waste, are also responsible for the highest amount of marine littering. China, Indonesia, the Philippines, Vietnam, Thailand, Malaysia, Bangladesh, Turkey and Pakistan are all in the top 15 when it comes to mismanaged plastic waste (Jambeck et al., 2015). Further, out of the 10 rivers which are responsible for 90% of the plastic waste in the oceans, 8 can be found in South-East Asia (UN, 2019). Furthermore, Turkey is considered the main polluter of the Mediterranean-Sea (ARD, 2019).

2.4 Policy for innovation

As the preceding section provided the reader with insights on the current structure of recycling of plastic waste and recent policy developments, the following section aims to set these insights into a more academic setting. Thus, the following section provides an overview of policy mixes for innovation and the field of sustainability transitions.

During the 1960s, the term "policy mix" emerged in the academic environment. In his studies of floating exchange rates, Robert Mundell has laid the foundation for an ambiguous academic discussion around the term (The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel, 1999). In this paper, the term "policy mix" is set into relation with innovation and understood as a set of policy instruments which aim to nurture innovation (Borrás & Edquist, 2013). However, the term "policy mix" is often treated as self-explanatory and thus, often remains under-conceptualised. This is also due to the complex nature of policies and the level of uncertainty they create, as potential outcomes are challenging to connect towards the initial instrument (Flanagan, Uyarra & Laranja, 2011). Nevertheless, it can be agreed on that policy mixes for innovation are often related to goals like economic growth and environmental protection (Borrás & Edquist, 2013).

In their study, Flanagan et al. (2011) stress that the interactions between different parts of the policy mix need further conceptualisation. As policy mixes for innovation are influenced by a range of different factors, concepts must go beyond the simple approach of using instruments as if they were tools which can be applied to any given case (Flanagan, Uyarra & Laranja, 2011). They stress that interactions can occur in different dimensions; policy space, governance space, geographical space and time. Further, they distinguish that instruments can interact through different types of interactions, i.e. through, for example, targeting the same actor or targeting different actors who are involved in the same process. This creates potential tensions between policy rationales, policy goals and implementation approaches (Flanagan, Uyarra & Laranja, 2011). It becomes evident that this basic approach towards the conceptualisation of interactions already creates a very complex network of different relations between cause and effect of policy instruments. Flanagan et al. (2011) thus stress that academia could re-conceptualise the fundament of policy instruments and how they are treated in innovation studies.

This thought of re-conceptualising policy mixes in innovation studies has echoed throughout different studies in the following years, which aim to create novel concepts. Magro and Wilson (2013), stress in their study the path-dependency of policies, as there is always a co-existence of policies with different rationales like neo-classical or evolutionary systems (Magro & Wilson, 2013). Thus, a linear evaluation approach of policies is too simplistic, therefore they propose a six-step evaluation process; first, draw the policy system and the boundaries considering the rationales, domains and instruments. Second, select a policy rationale, third, analysis of the mix of domains and instruments at different levels. The fourth step identifies evaluation practices and determines if they account for interactions between instruments. Step five conducts an integrated evaluation of policy instruments following the same rationale. The final step aims to integrate the evaluation of the rationale in a holistic evaluation, i.e. the evaluation mix. Steps three to five shall be repeated for each rationale (Magro & Wilson, 2013).

According to Magro and Wilson (2013), the evaluation of instruments should play a crucial role in the design of policy mixes and be part of the policy framework; they emphasise this for the reasons mentioned above for increased complexity in innovation policies (Magro & Wilson, 2013). Flanagan et al. (2011) have also stressed the issue of increased complexity in innovation policy mixes and called for novel approaches for the measurement of interactions between different policy rationales (Flanagan, Uyarra & Laranja, 2011).

Borras and Edquist (2013) also acknowledge the complexity of policies targeted towards innovation. However, they stress that the objectives of policies must play a central role when choosing instruments. As different objectives of policies can collide, for example, economic objectives versus environmental objectives; they must be at the core of policy design. Thus, the selection of instruments entails several different dimensions; first, the selection of specific instruments, second the customisation of chosen instruments and third the design of the instrument mix towards the ultimate objectives (Borrás & Edquist, 2013). Policy instruments occur in different forms and variations; regulatory, economic and financial and lastly as soft instruments. Regulatory instruments are for example able to ban single-use plastic products. The European Union has recently announced that a range of around 200 single-use plastics will be banned as they are a threat towards the environment. This regulation will affect actors within the industry as they will not be allowed to continue the production of single-use items (Kerstens, 2019). Financial and economic instruments could, in this case, entitle support for new solutions within the area of plastics, i.e. compostable bioplastics or plastics that are easily recyclable.

Further, the EU is introducing research and development funds that support the process of finding new solutions to the plastic problem (European Commision, 2018a). Both are examples where financial and economic instruments are used to incentivise the circular approach towards plastics. Soft instruments have gained popularity within the EU in the past decade; in the case of recycling, the EU sets targets for recycling rates for its member countries. However, these are non-binding and rather voluntary, considering that numerous countries are well below the target recycling rates (European Commision, 2019).

Borras and Edquist (2013) propose that their typology of instruments can be divided into four groups; provision of knowledge inputs for innovation, i.e. R&D; secondly, demand-activities, i.e. the formation of new product markets and quality regulations; thirdly, the rules of the game, i.e. changing the regulations to create novel systems of innovation and lastly support services for innovating firms like incubators. According to them, the demand side, where public agencies place orders for innovative solutions/products is often underrepresented (Borrás & Edquist, 2013). This can be observed in fields of this study as well, governmental policy in Germany has so far not demanded increasing action in areas like Bioplastics which could be one reason for the low growth rates in this industry sub-section (Lindner & Hoffmann, 2015).

2.5 Sustainability transitions in innovation policy

It becomes evident to the reader that innovation policy in the context of this paper is aimed towards environmental concerns and the plastic waste problem. As policy mixes are the overarching umbrella and a powerful tool, it is crucial to understand the functions and interactions of different policy instruments. However, in the past decades, a more inter-disciplinary study field has evolved around the concerns of sustainability. The field sustainability transitions combine various study fields from economic geography and environmental science to policy studies and considers state actors as well as non-state actors (Markard, Raven & Truffer, 2012). Research in this field goes in various directions and is profoundly concerned with policy instruments and how they nurture transitions towards sustainability. As transitions require general innovations, policy mix studies directed towards innovation are closely related to sustainability transitions. In this rather novel field of research, four conceptual approaches stand out; transition management, strategic niche management,

multi-level perspectives on sociotechnical transitions and technological innovation systems (Markard, Raven & Truffer, 2012).

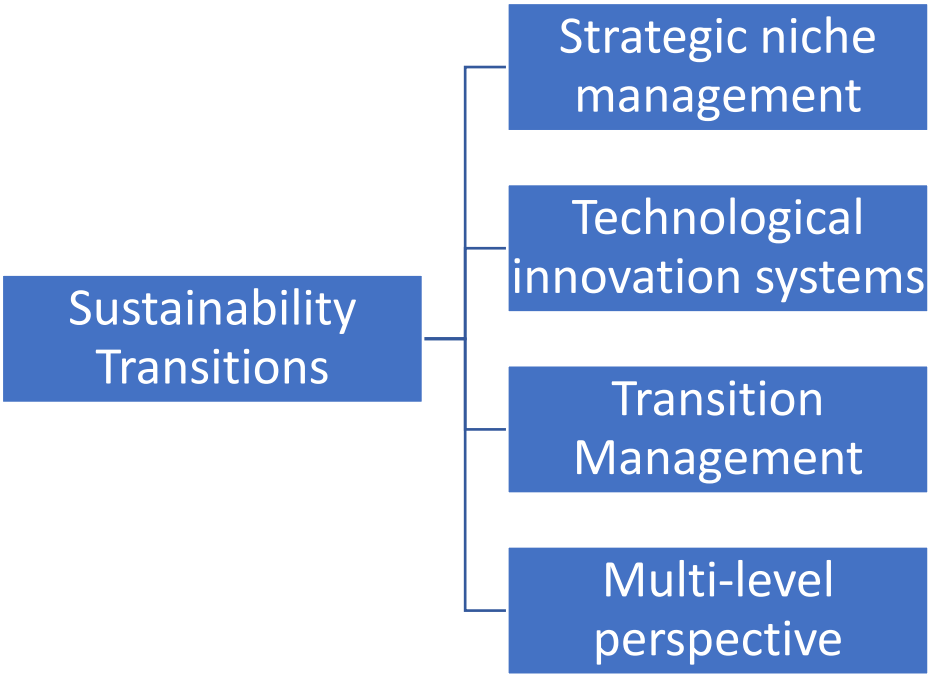

Figure 2: Simplified structure of the field "sustainability transitions"

(based on (Markard, Raven & Truffer, 2012))

Strategic niche management is concerned with the emergence of new technologies towards the market, i.e. the gap between invention and innovation. Raven and Geels (2010) have added considerable contributions to the field of strategic niche management by introducing conceptual frameworks which aim to provide a deeper understanding of the emergence of new technologies. In their conceptualisation of SNM, they stress the importance of interactions between different level-actors, i.e. the external environment like regimes, the niche level including emerging communities or market fields and local practises (Raven & Geels, 2010). By using Biogas as an example, they introduce the ups and downs in the development from invention to innovation. However, their concept fails to explain why niche development fails at certain stages of the development process. Further, the study has minor conceptual flaws, considering the relation of lobbying and policy (Raven & Geels, 2010). Lobbies can be influential players by influencing policymakers and need consideration in models for niche innovations, especially when niches would make existing industries obsolete.

If niches eventually evolve, they may form technological innovation systems. Studies in this area are also concerned with a development similar to SNMs. However, they focus on the dynamics and interactions in already existing technological systems not the ones who may become a technological innovation system (TIS) one day. In their landmark study, Bergek et al. (2008) have conceptualised a framework which enables policymakers to analyse technological innovation systems with regards to key-policy issues and the dynamic interactions between different actors within the TIS. The framework proposes a six-step process in which the TIS and its actors are identified, the functions/dynamics are set into relation with the achievements of the TIS and then evaluated with regards to a policy which identifies key-policy issues (Bergek et al., 2008). Thus, it is evident that the frameworks focus lies on the outcome of TIS rather than the structure of the TIS. This may pose difficulties as TIS structure is often crucial to develop policies that nurture the innovation systems. Further, Berger et al. (2008) stress that the framework is limited to the extent that it does not consider how TIS are established as it only considers already existing TIS (Bergek et al., 2008).

One approach which may fill the gap between existing TIS and the creation of TIS is transition management. This approach is concerned with the structural change in socio-technical systems. Often it is used in the field of sustainability transitions to investigate how the energy sector can be transformed towards a more sustainable system (Kern & Smith, 2008). Transition management is profoundly concerned with the ideal vision of the future, i.e. a sustainable structure in complex socio-technical systems. Kern and Smith (2008) proposed the model of "transition experiments" to bypass the existing regimes in the energy sector and test innovations to put pressure on the energy regimes. By creating equal chances for all market players through policy interventions, they stress that the most sustainable approach will evolve (Kern & Smith, 2008). However, the transition management approach has some fundamental difficulties as existing regimes, especially the energy sector, have considerable influence on policymakers. Thus, it will be difficult to bypass them and weaken their position in the market field.

Further, they have developed influential lobbies which have considerable influence on policymakers. Moreover, energy supply is crucial for societies to function and thus, is a highly complex field for policymakers. Loorbach and Rotmans (2010) have acknowledged these difficulties and proposes a framework for transition management which includes "transitions experiments" and adds an additional dimension which includes continuous evaluation and monitoring of the experiments which then leads to a redefinition of the sustainable vision which initially created the transition experiments. They distinguish between four behaviours that

actors show in the transition process; strategic, tactical, operational and reflexive (Loorbach & Rotmans, 2010). Considering the strategic behaviour of, for example, firms, policy instruments can be designed and aligned to create a transformation process. However, as with many of the previously discussed approaches, we can observe a lack of destructing and destabilising approaches. The transition management approach aims for the creation of experimental technologies and transition processes but does not focus on the destabilisation of existing regimes. This is a crucial point as especially the energy sector, and in this case, the plastic industry has a definite position on the market. In order to create transformation, destabilisation and withdrawal of support for existing regimes must be at the core of transformative processes.

Considering destabilisation, the multi-level perspective for sustainability transitions delivers more promising concepts. Geels (2011) has provided extensive insights into the multi-level perspective (MLP) approach. According to Geels, MLP transitions are a non-linear process where actors interplay on different levels. These levels are; niches, socio-technological regimes and an exogenous socio-technical landscape (Geels, 2011). The advantage of the MLP approach is that it goes deeper into other complex environments of well-established systems, one example could be the invention of the car; it plays a central role in today's world and touches a lot of different systems like transportation, personal values and industries. With the proposed approach by Geels (2011), these complex environments can be analysed and actions towards sustainability transitions formulated. However, the model received considerable criticism from several scholars, as Geels (2011) acknowledges, especially considering the specification of regimes, the bias towards a bottom-up approach and the difficulties in selecting sufficient data (Geels, 2011).

As the initial MLP approach by Geels lacked, like most models, the destruction and destabilisation mechanism, he extended the framework in later work together with Turnheim (2013). In their extension, which builds on the triple embeddedness framework (MLP), they give valuable insights on regime destabilisation in the MLP. According to them, destabilisation can happen through three core dimensions; the flow of financial resources, support from a wide range of stakeholders, i.e. the public, and the level of trust to existing industries. However, destabilisation can face challenges through several lock-in mechanisms; shared mindsets within the system, strong industry mission, technical knowledge and policy regulations. Destabilisation processes can overcome these challenges by assembling external pressure on industries, which ultimately should lead to performance problems of the industry. Thus, the existing industry regime will weaken continuously, and destabilisation can take place.

Nevertheless, they acknowledge that destabilisation is a multi-faceted and complex process and propose that a somewhat flexible approach in combination with other frameworks should be an issue for future research place (Turnheim & Geels, 2013).

It becomes evident that even models which consider destabilisation methods have weaknesses. The issues with the understudied field of destabilisation is not a new issue in the field of sustainability transitions. Meadcrowth (2009) already acknowledges the difficulties of lock-ins, i.e. the problem with stable regimes (Meadowcroft, 2009). In earlier work, Scrase and Smith (2005) have also stressed the importance of increasing pressure on existing regimes to enable sustainability transitions (Scrase & Smith, 2009). Thus, taking a step back to reconsider existing frameworks may be one approach. Shove and Walker (2007) stress that the field of innovation studies should step back from the perspective that the MLP framework is the ultimate ratio of sustainability transitions (Shove & Walker, 2007).

2.6 Creation and destruction in sustainability transitions

A novel framework in innovation policy and sustainability transitions aims to fill the gap of analytical frameworks that lack destabilising approaches. Kivmaa and Kern. (2016) introduce an analytical approach which is coined by the idea of "creating" innovation and "destruction/destabilising" exiting regimes. This overarching thought was coined by Joseph Schumpeter, who defined the term "creative destruction" as the driving force in the market, in which innovations make old technologies obsolete (Kivimaa & Kern, 2016). In their framework, Kivmaa and Kern (2016) introduce a total of eleven dimensions; seven creation dimensions and four destructions/destabilising dimensions. By building upon the TIS approach and combining it with the SNM approach, they aim to create a framework which evaluates policy mixes both under the consideration of innovation creation and destabilising approaches towards exiting regimes.

CREATION:

C1: Knowledge creation, development and diffusion: R&D funding schemes, innovation platforms, i.e. policies aiming for the creation of innovation and new knowledge

C2: Establishing market niches/market formation: Tax exemptions, regulations that aim to support developing markets.

C3: Price performance improvements: Subsidised and R&D support, i.e. helping developing niches to be able to compete with existing regimes.

C4: Entrepreneurial experimentation: policies supporting start-ups such as advice for SMEs.

C5: Resource mobilisation: Human (educational) and financial (R&D funding) support.

C6: Support from powerful groups/ legitimation: Public procurement to create legitimacy for new solutions.

C7: Influence on the direction of search: Goal definition and framing strategies.

DESTRUCTION

D1: Control policies: Policies such as taxes, import/export restrictions and regulations.

D2: Significant changes in regime rules: Policies aiming for structural reforms

D3: Reduced support for dominant regime technologies: Withdrawing support for technologies in existing regimes.

D4: Changes in social networks, replacement of key actors: Formation of new networks that are tied to desired systematic change.

(Kivimaa & Kern, 2016)

As this novel approach to sustainability transitions combines several approaches, it is a promising advancement in the field. Nevertheless, the novel focus on both creation and destruction of technologies and regimes is a promising analytical tool. In the following analysis the dimension D1 will be of crucial importance as this study focuses on the exports and imports of German plastic waste to countries which mismanage waste. Trade restrictions are an important part of a sustainability transition policy mix according to Kivimaa and Kern (2016) and thus, with regards to the research questions, stand in the focus of the proceeding analysis. However, this study cannot analyse the remaining dimensions on both the creation and destruction side, as this is beyond the scope of this thesis.

2.7 Scope of the study

Following the general structure of the reviewed literature, it becomes evident that policy mixes for innovation and sustainability transitions are closely related. Further, the presented literature indicates that the vast majority of studies concerned with sustainability transitions have dealt with issues like energy and transportation (Markard, Raven & Truffer, 2012). Moreover, scholars have emphasised that destructive policies in policy mixes are underrepresented. Thus, the scope of the following analysis is to present a first step towards analysing the sustainability transitions regarding the plastics industry network and the resulting plastic waste it ultimately produces. As plastic and plastic waste occur in a complex network, this study does not aim to deliver final solutions to the problem. It is rather a proof that the field can and should be studied to a larger extent.

By focussing on the D1 (import/export restrictions) perspective of Kivimaa and Kern (2016), this study aims to investigate further what impact policies have on Germany's exports and imports of plastic waste to Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey.

3 Data

3.1 Description of data

As the preceding section has established a solid discussion of the existing literature and research approaches within the field of policy for innovation and sustainability transitions, this section aims to provide further insight on the secondary data used. As this study is concerned with the plastic waste imports and exports to and from Germany, the logical approach is to use data which presents imports and exports of German plastic waste.

The chosen dataset are the imports and exports of "Waste, pairings and scrap of plastic" as found in the 4-Digit customs code "3915". Similar data has been used in previous research by Brooks et. al (2018) in their analysis of waste streams following the import ban of plastic waste to China. The dataset includes plastic categories like PE, PS, PVC and other plastics which are not yet harmonized by the UN i.e. PET and PP (Brooks, Wang & Jambeck, 2018).

In order to analyse the destructive dimension of import/export restrictions introduced by Kivimaa et.al (2016), the import and exports of Germany to a selection of partner countries were extracted from Comext. Comext is based on the statistical reports of the countries within the EU and created by Eurostat (European Commission, 2019). As Comext is a frequent tool for users of statistical data, it offers the opportunity to customize the datasets. This makes it easier for researchers to only extract the exact data needed (Eurostat, 2019). When accessing Comext, researchers have the selection of a variety of datasets. The one in for this study can be found under "International Trade" – "Extra EU trade since 2000 by mode of transport".

In Appendix A, a detailed presentation of the used data can be found. The reporting country in our study is, of course, Germany. On the horizontal "Partner" row the countries Germany is conducting trade with are represented. The partner countries include: Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Philippines, Thailand, Turkey, Taiwan and Vietnam. The selection of these specific partner countries is based on the fact that these countries have high rates of mismanagement of waste (Jambeck et al., 2015). It must be acknowledged that the analysed dataset represents amounts which were transported by sea. This form of transport is

the foundation of the dataset as it represents the most common form of delivery of goods from Germany to Asia for plastic goods.

3.2 Limitations of dataset

As plastic waste trade is only subjected to notification but is not restricted, the German government has to be notified when plastic waste is traded (Lehmphul, 2014). Thus, the dataset used in this case can be considered a reliable resource as it contains official governmental data provided by the statistical department of the European Union (European Commision, 2019a). However, the dataset does not differentiate between the different plastic types. This is a limitation as it cannot be differentiated if some plastic types are exported and imported in higher quantities than other types of plastic. Nevertheless, the dataset does provide reliable insights into the imports and exports of German plastic waste from 2000-2018. In spite of this, the data lacks a few indicators for some years, as either no trade occurred, or nothing was reported. Furthermore, it needs to be stressed that the availability of the data to the general public is somewhat controversial. The German Environmental Department only offers the cumulative exports and imports of plastic waste and does not clearly specify to which country waste is exported. For more detailed data, extensive research, in databases like Comext, is required in order to obtain the data.

4 Methods

As the data section already indicated, the focus of the analysis will deal with import and export statistics from Germany with Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey. The following section aims to describe the motive and method for the proceeding analysis. As the focus lies on "3915 Waste, scrap and pairings of plastics" the analytical focus will be intra-industry trade. Thus, the trade of "equal" goods between countries. In the following discussion, a basic description of the calculation of an intra-industry index defined by Grubel and Lloyd (1975) and the reasons for the choice of this indicator, will be presented (Grubel & Lloyd, 1975). Further, the section will stress the limitations of the analysis and indicate the chosen focus i.e. the selection of countries that will be discussed.

4.1 Grubel Lloyd Index as an analytical tool

Intra-industry trade can be understood as trade between countries, where goods from the same industry are exchanged. The literature distinguishes between two types of intra-industry trade; horizontal and vertical. Horizontal intra-industry trade is the trade of goods which are at the same production stage i.e. in our case plastic waste and plastic waste. Vertical intra-industry trade refers to goods at different stages of production i.e. plastic waste and for example recycled plastic which could be used as resource in the production process (Grubel & Lloyd, 2007).

In the analysis the focus will lay on horizontal intra-industry trade as the traded product category "3915 Waste, scrap and pairings of plastic" does not allow interpretation for what stages of the production/recycling process the imported and exported products are.

The following formula is one way of calculating the Grubel-Llyod Index and shall serve as the analytical tool.

$$GL_{sector\ i} = 1 - \left(\frac{|exports_{sector\ i} - imports_{sector\ i}|}{exports_{sector\ i} + imports_{sector\ i}}\right)$$

(Grubel & Lloyd, 1975)

If Germany only exports goods or only imports goods, the index will be zero. Logically, if Germany imports and exports goods, the Index will be closer to one (WTO, 2012). If exports and imports are equal, the Index will be exactly one. Further, if the exports are half of the imports, the index will be precisely 0.66 (Grubel & Lloyd, 1975). Thus, the Grubel-Lloyd index will be somewhere between zero and one, indicating whether Germany exports more plastic waste than its importing or the other way around. If the GL Index is approaching zero, the literature indicates that this a sign for inter-industry trade, i.e. Germany is selling plastic waste and is, for example, important manufactured goods from the trade partner (Hamilton & Kniest, 1991).

4.2 Example of calculation

In order to illustrate the Grubel-Lloyd index the following example illustrates the calculation and potential interpretation;

(1) $$GL_{sector\ 3915} = 1 - \left(\frac{|exports_{sector\ 3915} - imports_{sector\ 3915}|}{exports_{sector\ 3915} + imports_{sector\ 3915}}\right)$$

The following calculation does not represent actual data it only aims to illustrate the applied method in order to guarantee that readers can replicate the method.

(1.1) $$GL_{sector\ 3915} = 1 - \left(\frac{|500{,}000€_{sector\ 3915} - 100{,}000€_{sector\ 3915}|}{500{,}000€_{sector\ 3915} + 100{,}000€_{sector\ 3915}}\right)$$

Thus,

(1.2) $GL_{sector\ 3915} = 0{,}333$

This example illustrates that Germany is exporting considerably more plastic waste than its importing and it may be a sign of inter-industry trade. However, the main point is to stress the imbalance in trade between the two countries by showing the higher exports of Germany to country X.

4.3 Limitations of the Index

Due to the simplicity of the index, it bears some limitations. One limitation is the aggregation problem, i.e. the index picks up vertical trade if not calculated at a detailed level. One example could be that certain products get exported by Germany, to be assembled in a different country and then get imported again. This could show high levels of intra-industry trade even if goods just get exported for the sake of lower assembly costs in another country (WTO, 2012).

A second limitation or problem is the classification of the traded goods; if one considers the chosen product "3915 Waste, scarp and pairings of plastic" it becomes evident quickly that this classification includes a variety of different products. This is due to the fact that plastic types like PET are not harmonized by the UN yet. Further, the classification does not deliver insights in what quantities different plastics are traded, even if harmonized. This is beyond the scope of this study. Further, the GL Index may show that Germany is exporting a lot but does not consider the imports of other goods which are not covered by the classification. Thus, cross-industry trade is not covered by the Index (Harrigan, 1994).

Thirdly, the GL Index, only shows the balance of exports and imports within the analysed category. Thus, it does not deliver information on how much is exported or imported. However, this limitation can be overcome by comparing the index results to the total exports to gain a deeper understanding of the results.

4.4 Reasons for choosing the index despite limitations

However, the index is chosen as an indicator in this analysis for the simple reason that it emphasises the imbalance between exports and imports in intra-industry trade. As the index is applied for the period of 2000 until 2018, it can further point out the potential imbalance over the years. When analysing Germany's trade with Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey, the index can clearly emphasize if the imports and exports are in balance or not. Further, as this thesis aims to stress the importance of destructive policies to enhance sustainability transitions, developments observed in the index can be set into relation with policy developments. Furthermore, the GL Index will be set into relation with the amount of total exported tonnes to Germany's trade partners to gain deeper understanding of the results and the development of the index over the period from 2000 until 2018.

4.5 Focus areas

The preceding analysis will focus on a selection of countries for several reasons. As described in the literature review, Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey, have shown high levels of mismanagement of plastic waste and insufficient waste collection. Furthermore, as stressed by Jambeck et al. (2015), the rivers in these Asian countries are responsible for the majority of plastic waste in the Oceans (Jambeck et al., 2015). Moreover, Turkey is accused of being the main polluter of the Mediterranean Sea (ARD, 2019). Thus, these countries shall be analysed in terms of imports and exports of plastic waste with Germany as a trade partner.

5 Empirical analysis / results

In the following analysis, the results of the Grubel Llyod index will be presented for Bangladesh, China, Hong Kong, Indonesia, India, Malaysia, Thailand, Turkey, Taiwan and Vietnam. Furthermore, the Grubel Llyod index for all trade outside of the EU conducted by Germany is presented as “EU 28 Extra”. However, it is crucial also to consider the exports of plastic waste. This is because Jambeck et al. (2015) have stressed that these countries show high rates of mismanagement of plastic waste (Jambeck et al., 2015). The presented results will be analysed under consideration of the discussed literature and current advancements in policy. Furthermore, policy implications and potential impacts of recent policy advancements will be set into relation with the analysis.

5.1 Results Grubel LLyod Index

Table 2: Grubel Llyod Index Results for Germany and trade partners 2000 – 2018

…	PARTNER	Banglades	China	EU28_EXTRA	Hong Kong	Indonesia	India	Malaysia	Thailand	Turkey	Taiwan	Vietnam
REPORTER	PERIOD/PRODUCT	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915
DE	2000	n/a	0.0401	n/a	0.0001	0.0000	0.00841	0.0664	0.6383	0.0000	0.9796	n/a
DE	2001	n/a	0.0000	n/a	0.0000	0.0000	0.00000	n/a	n/a	n/a	0.1816	n/a
DE	2002	n/a	0.0002	0.0423	0.0000	0.0000	0.01231	n/a	n/a	0.5074	0.0601	n/a
DE	2003	n/a	0.0023	0.0187	0.0000	0.0000	0.00000	0.0000	0.0000	0.0000	0.0000	n/a
DE	2004	n/a	0.0006	0.0146	0.0000	0.0000	0.00000	0.0057	n/a	0.0000	0.1937	0.0000
DE	2005	n/a	0.0001	0.0109	0.0000	0.0000	0.00000	0.0000	n/a	0.0017	0.0411	0.0000
DE	2006	n/a	0.0004	0.0197	0.0016	0.0000	0.06223	0.0000	n/a	n/a	0.0626	n/a
DE	2007	n/a	0.0008	0.0167	0.0000	0.0000	0.00166	0.0000	0.1342	0.0101	0.0215	0.0000
DE	2008	0.026397	0.0006	0.0164	0.0000	0.0000	0.00324	0.0140	n/a	0.5649	0.0545	0.0000
DE	2009	0	0.0002	0.0068	0.0000	0.0000	0.00000	0.0000	0.0182	0.0000	0.0000	0.0000
DE	2010	0	0.0001	0.0113	0.0000	0.0000	0.00201	0.0000	0.0000	0.0170	0.0420	0.0000
DE	2011	0	0.0015	0.0105	0.0000	0.0000	0.00340	0.0000	0.0746	0.2801	0.0006	0.0000
DE	2012	n/a	0.0005	0.0126	0.0007	0.0086	0.00324	0.0085	0.0000	0.0339	0.0267	0.0000
DE	2013	0.420341	0.0003	0.0072	0.0000	0.0000	0.00059	0.0000	0.1684	0.0000	0.0000	0.0000
DE	2014	0.004272	0.0003	0.0063	0.0000	0.0542	0.00028	0.0000	0.2850	0.0690	0.0028	0.0000
DE	2015	0	0.0006	0.0108	0.0000	0.0000	0.00000	0.0000	0.0000	0.0093	0.0010	0.0000
DE	2016	0	0.0011	0.0177	0.0000	0.0000	0.00007	0.0023	n/a	0.0034	0.0052	0.0000
DE	2017	0	0.0004	0.0199	0.0000	0.0345	0.00162	0.0012	0.0000	0.0241	0.0418	0.0000
DE	2018	0.023944	0.0521	0.0776	0.0000	0.0031	0.00351	0.0000	0.0554	0.0011	0.0002	0.0000

5.2 Observations Grubel Lloyd index

When looking at the table which presents the Grubel Llyod index, it becomes evident on first sight that the results are very unbalanced. When considering Bangladesh, it becomes evident that the index was "n/a – not applicable" for the period from 2000 until 2007, including 2012. This is because the data for these years was either not available, or no imports and exports of plastic waste took place. However, the development from 2008 until 2018, shows that Bangladesh eventually became a trading partner for Germany and considering the low Grubel Llyod index, it becomes evident that Bangladesh was receiving more plastic waste than it sold back to Germany. Similar results occur for China; it becomes evident that the exports outnumber the imports considerably. However, in 2018 the index showed a sharp increase to almost 5%, which is still very low but shows that exports may go down. This is also reflected in the GL Index for Hong Kong, which is zero in almost all years because exports outnumber the imports considerably. Hong Kong often acts as the first point of entrance for products that flow to China. In the case of Indonesia, we can observe index results which are almost in every year zero or close to zero, which indicates high exports and low imports. India shows, similar results, but more numerical i.e. not exactly zero, thus some imports seem to be flowing to Germany. For Malaysia, it can be observed that the years 2001 and 2002 do not provide any data, but the preceding years show low results around the 1% mark. Furthermore, the data for Thailand is not applicable in seven years, which is a sign for inconsistent trade, in 2014 the index increased to 28%, which may be a sign for decreasing exports. However, in the following years the index decreased again to zero. Turkey shows signs of imbalanced trade in recent years, in the past imports and exports have been more balanced compared to other countries, especially in 2002 and 2008. However, since 2014 the index is below the one percent mark which indicates increasing exports. Interesting developments can be observed in Taiwan, where the index in the year 2000 indicated balanced trade with 97% but steadily decreased to 0.1% in 2018. Finally, Vietnam shows that virtually no imports take place as the index is zero for all years.

Nevertheless, if we consider the below illustrated figure which indicates the development of the Grubel Lloyd index for Germany and the total extra EU trade, we can observe that since 2013, the exports seem to be decreasing. Historically we can see that the Grubel Lloyd index was around the one percent mark. However, in recent years it rose up to almost 8%. This development started in 2013, which may be related to the introduction of the Chinese Greenfence. But still, even the increasing index still shows that Germany is exporting considerably more plastic waste than it is importing.

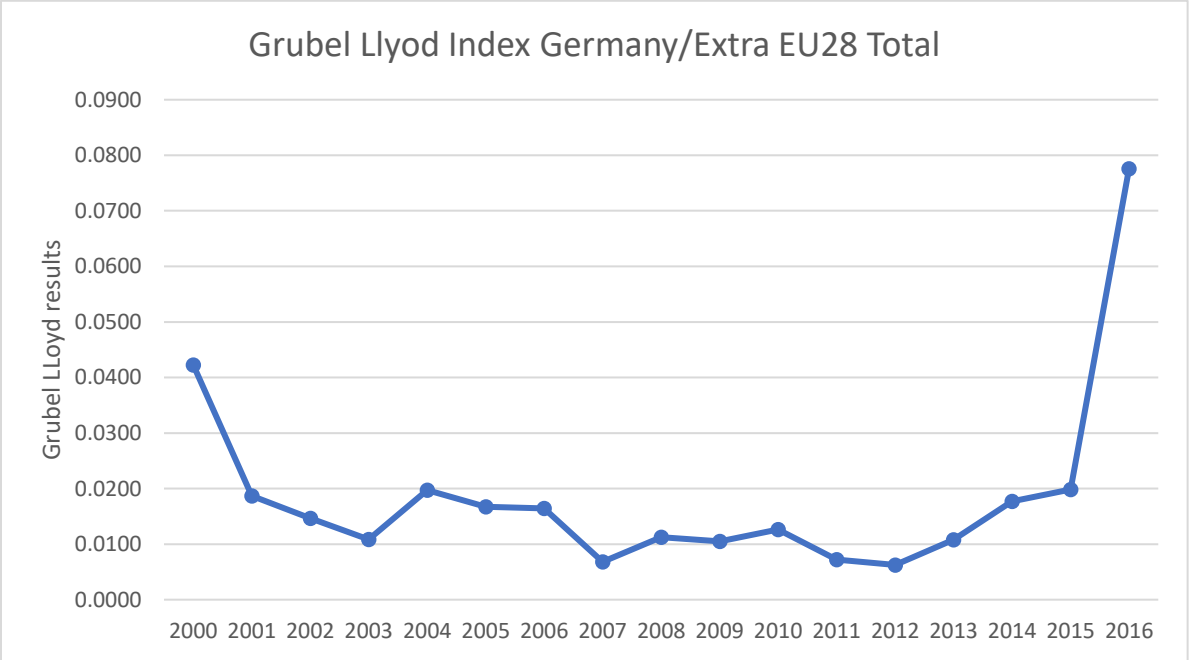

Figure 3: Grubel Lloyd Index for Germany and the combined extra EU28 trade

As observations indicate that Germany is exporting plastic waste to all these countries in much higher quantities than it is importing plastic waste. It becomes evident that the exports of the analysed period need further analysis, as these countries mismanage by average, 68% of their waste (Jambeck et al., 2015).

In the following section, on the basis of the GL index, the exported amounts of plastic waste will be set into relation to the literature and relevant policy decisions that may influence the movements of plastic waste.

5.3 Results in relation to exports

When considering the GL index for China, Hong Kong and the extra EU trade, it becomes evident that the Greenfence had a considerable impact on the trade relationship. China was by far the largest importer of German plastic waste with almost 800,000 metric tonnes in 2009. Since the Greenfence was implemented in China, the imports went down to only 13,455 tonnes in 2018. As China's Greenfence bans all household plastic waste imports, it becomes evident that most exports of Germany to China fell into that category. Similar developments can also be observed in Hong Kong which often serves as an entry port for imports to China, since 2014 the German exports to Hing Kong have decreased by more than 50%

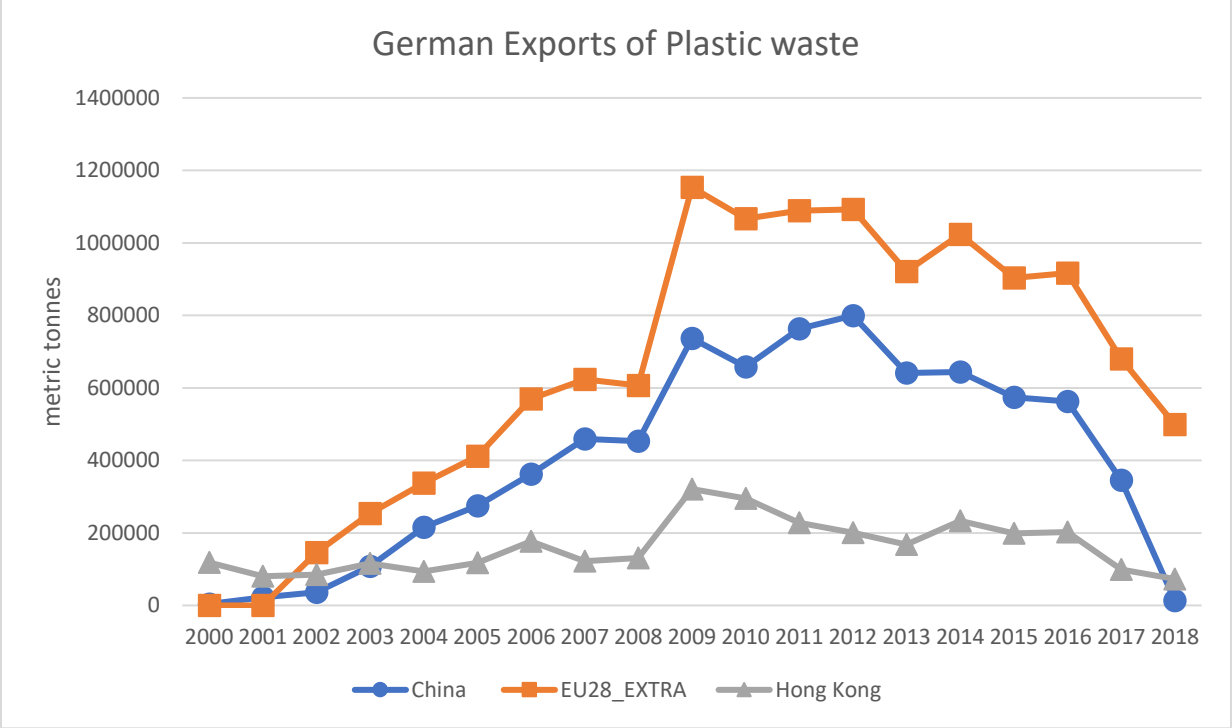

Figure 4: German plastic waste exports in metric tonnes to: China, Hong Kong and total Extra EU28 2000 – 2018

When considering the literature for sustainability transitions, one can consider China's Greenfence as a destabilising/destructive policy measure. As China's Greenfence includes trade policy, i.e. import restrictions, it falls into category D1 of the framework proposed by Kivimaa and Kern (2016). Thus, Chinese import bans may have considerable influence on the future development of the recycling market and plastic production in Germany (Kivimaa & Kern, 2016). However, as China is not allowing imports of plastic waste anymore, other regions must

receive more plastic waste This is due to the fact that extra EU trade of plastic waste may decrease, but Germany still exported around 500,000 metric tonnes of plastic waste in 2018.

Following the GL index for Vietnam, Malaysia, India and Indonesia, the results indicate that Germany is mainly exporting to these countries as well. However, the total amount of metric tonnes becomes of interest. As we can observe in the figure below, since the introduction of the first measures of the Greenfence in 2013, exports to these countries have increased considerably. Malaysia received 11,356 tonnes of plastic waste in 2012; this number grew to roughly 130,000 metric tonnes in 2018. Similar drastic developments can be observed in Indonesia where the German exports accounted for small quantities of under 1000 tonnes per year until 2018, where the country received around 64,000 tonnes of German plastic waste. India has historically received larger quantities of German plastic waste. However, it has seen a sharp increase from 2017 to 2018 from 41,000 tonnes to 64,000 tonnes.

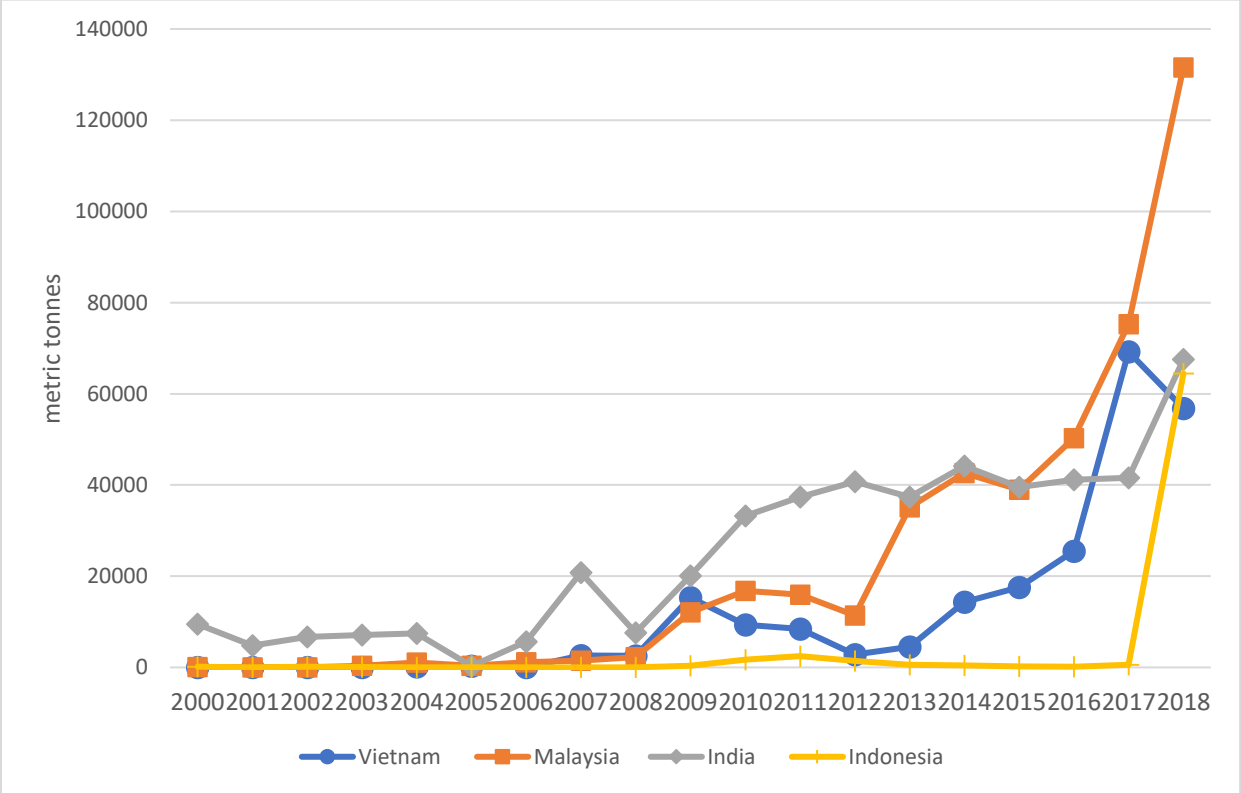

Figure 5: German plastic waste exports in metric tonnes to: Vietnam, Malaysia, India and Indonesia 2000 – 2018

As "Figure 5" indicates, the development has been quite extreme since 2013; we can find similar results for Bangladesh, Thailand and Taiwan in "Figure 5". However, albeit in fewer quantities. The GL indicates for these countries as well that Germany in mainly exporting plastic waste. Since 2013 Bangladesh has become a steady importer of German plastic waste,

historically it only traded with Germany from 2008 onwards. However, since 2013, the imports of plastic waste from Germany have been around 3,500 tonnes per year. For Taiwan, we can observe an increasing amount of imports from Germany since 2013 as well. However, the imports dropped in 2017 to only 1480 metric tonnes followed by a peak in 2018 of 8175 tonnes.

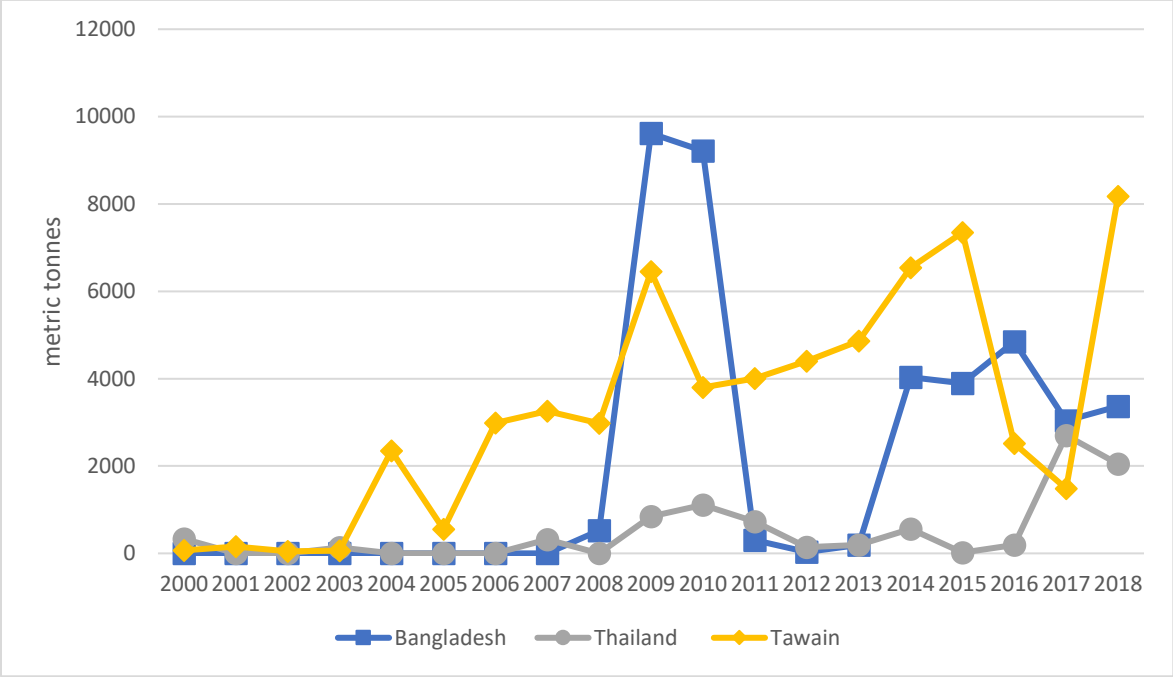

Figure 6: Germany plastic waste export in metric tonnes to: Bangladesh, Thailand and Taiwan 2000 – 2018

The results for Turkey may seem a bit out of the region. However, Turkey is suspected of being the main polluter of the Mediterranean Sea (ARD, 2019). This, in combination with high percentages of mismanaging waste (Jambeck et al., 2015) makes it a crucial point of analysis when it comes to trade of plastic waste. As "Figure 6" indicates, we can observe an extreme increase of plastic waste exports to Turkey from Germany since 2016. From only 3461 tonnes in 2015 to almost 50,000 tonnes in 2018.

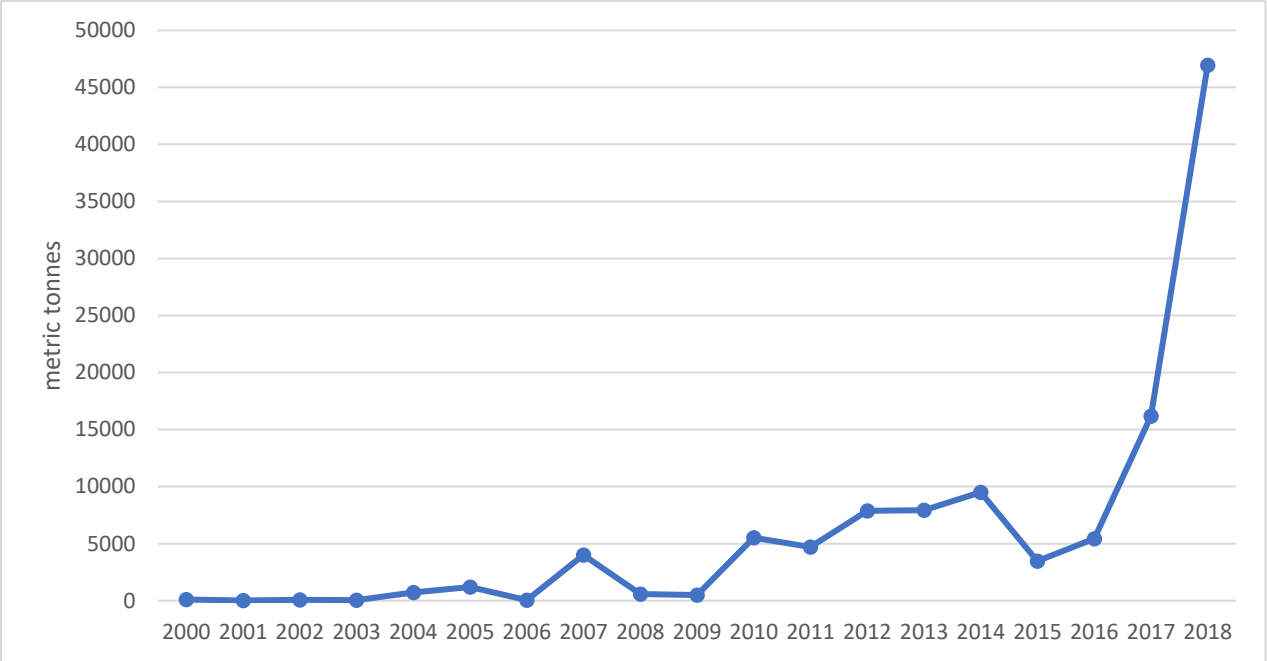

Figure 7: German Plastic waste exports in metric tonnes to Turkey 2000 - 2018

When considering the presented results, it becomes evident that there is a lack of control policies for the trade of plastic waste. The current plastic regime in Germany is built on the economic incentive that plastic waste gets exported for recycling (Örtl, 2019). As Kivimaa and Kern (2016) pointed out in their policy framework, the change of regimes needs a set of creation policies that fosters innovation and new solutions which make the current regime obsolete. However, they also stress the crucial importance of destruction policies that support the innovations and withdraw support of the current regime (Kivimaa & Kern, 2016). As the analysis shows, the current regime in Germany is not facing enough destruction policies to sufficiently change the current plastic regime, the exports of plastic waste have been increasing until the introduction of the Chinese Greenfence. Since then the total exports to countries outside of the European Union may have decreased considerably. However, we also find that plastic waste is flowing to other countries in increasing quantities. Kivimaa and Kern (2016) describe their D1 dimensions as import and exports restrictions, which can put pressure on current regimes. In this case, we can observe destruction policies from foreign countries. China's Greenfence seems to be the primary driver as it was historically the largest importer of German plastic waste (Brooks, Wang & Jambeck, 2018). Furthermore, the new plastic strategy by the EU, which aims to create a circular plastic economy and make all plastic products in the EU recyclable by 2030, may foster innovation as it includes a monitoring framework that aims to support research and development (European Commission, 2018a).

5.4 Policy implications

By observing the results, it becomes evident to the reader that recycling rates in Germany are artificially high by exporting plastic waste to countries for recycling purposes. These countries have been found to have insufficient waste management systems and mistreat large proportions of plastic waste (Jambeck et al., 2015). In more relatable terms, this means that recycling in these countries is inefficient and often conducted in illegal facilities as presented by Greenpeace in their recent study (Greenpeace, 2018). Thus, Germany needs to take policy actions. As of this year the recycling target for plastic waste has been raised to 58,5% from previously 36%. From 2022 it increases further to 63% (Bundesgesetzblatt Teil I, 2017). These recycling targets put immense pressure on the recycling systems in Germany. As our results have presented, in the past even with low recycling targets, Germany was not able to recycle its own plastic waste. Furthermore, China will not start to import plastic waste again, as they produce increasing amounts of plastic waste themselves (Brooks, Wang & Jambeck, 2018).

Thus, Germany has simply speaking two options; find new trade partners which will take increasing amounts of plastic waste because more plastic waste needs to be recycled or take policy actions to solve the plastic waste problem at home.

As the framework presented by Kivimaa and Kern (2016) offers implications both on the creation and the destruction dimension, German policy makers should take their findings into consideration. They stress the importance of the D1 dimension which includes import and exports restrictions (Kivimaa & Kern, 2016). In Germany these restrictions are simply not existing. The new packaging law which became effective this year, does not cover explicit regulations on the trade of plastic waste (Bundesgesetzblatt Teil I, 2017). The current law simply classifies plastic waste as a traded product, of which the government has to be notified, but it is only subject to very few restrictions (Lehmphul, 2014). With the increasing recycling quotas, Germany needs to introduce destructive policy measurements to weaken the current regime in which plastic waste is flowing uncontrolled to countries which need plastic waste the least. Furthermore, the current policy structure in Germany creates incentives in Bangladesh, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey, to not improve their own waste management systems. When German plastic waste exports flow to these countries, it will remain unlikely that they will improve their treatment of waste as the waste treatment facilities are filled with the imported waste. China and Hong Kong have with the Greenfence set an

example of a first step towards more efficient waste management. However, this increased pressure on the other analysed countries as we observed, the German exports to these countries increased considerably since the introduction of the Greenfence.

6 Conclusion

6.1 Main results

The overarching aim of this study was to stress the plastic problem and take the first step in the direction of studies on plastic related policies in the field of sustainability transitions. As Markard et al. (2012) stressed in their findings, the field is relatively novel and growing, with increasing publications per year (Markard, Raven & Truffer, 2012). The research questions of this study were twofold:

How did imports and exports of plastic waste in Germany develop since the year 2000?

and

What policy mechanisms are in place in Germany to prevent the export of plastic waste to countries where plastic waste is mismanaged?

These research questions aimed to investigate how exports and imports developed since 2000 as increasing exports of plastic waste can be a sign of an insufficient recycling system in Germany. Further, in relation to the framework of Kivimaa et al. (2016), the question arose what policy mechanisms are in place to destruct/disrupt the current regime.

The Grubel Lloyd index clearly indicates that Germany is exporting larger quantities that it is importing. We find in our analysis that Germany's exports have been increasing drastically from 2000 until 2009. Between 2009 and 2013, the exports remained relatively stable. However, since the introduction of the Chinese Greenfence, the exports of plastic waste have decreased by almost 50%. Nevertheless, as China is not accepting plastic waste anymore, the plastic waste flows in increasing quantities to Bangladesh, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and Turkey. We can observe that Chinese policies act as an external disruptor of the market forces and cause disruptions in the current plastic regime.

Considering the second research question, it became evident that the policy control of exporting plastic waste to Bangladesh, Indonesia, India, Malaysia, Thailand, Taiwan, Vietnam and

Turkey simply is not existing in a sufficient framework. Policies like the new packaging law will increase the producer's responsibility and aim to increase transparency in the marketplace. However, as of today, plastic waste is a traded good that can be sold to any country as long as it is exported for recycling purposes. This is highly questionable as the majority of the plastic waste flows to countries which have virtually no sufficient waste management systems in place. German plastic waste exports to these countries counteract incentives to create waste management systems. Logically, as waste is flowing in already to existing recycling facilities – why should they collect their own waste. During the process of writing this thesis, 180 countries have agreed to include plastic waste in the Basel Framework of international trade. This means that plastic waste will be treated in the near future as hazardous waste, which makes its trade increasingly difficult. However, as nothing is set in stone yet, it is not clear if destructive policy measure will be put in place.

6.2 Limitations and future direction for research

When considering the dataset and the chosen method, it becomes evident that there are limitations to what the analysis can offer. As the dataset is based on "3915". The data does not show how PE, PVC, PP, PET and PS are divided into the data; the data does merely show the imports and exports of the combination. Further, the method applied can merely show the imbalance between exports and imports in intra-industry trade, but not how many goods Germany imports which are produced in the countries it sells plastic waste to. The analysis bears the limitation that it shows the Grubel Lloyd Index in combination with the total exports; recent policies in China had a visible effect on the development. However, new policies, like the packaging law in Germany or the EU strategy to target plastic waste, cannot be set into relation with the results sufficiently. We can merely conclude that there is a lack of destructive policies in the past and present. This is where future research can fill in. As stressed by Markard et al. the field of sustainability transitions has been profoundly concerned with energy (Markard, Raven & Truffer, 2012). However, in the future research should consider the new policies which have been implemented this year or will be implemented in the future. Future research can surpass the limitations of this thesis and set the policy frameworks into relation with the proposed framework by Kivimaa et.al. Thus, research can evaluate the effectiveness of the new policy measures by comparing new developments to the historical developments shown in this study.

7 References

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8 Appendix

8.1 Appendix A

Table 3: Exports in Tonnes from Germany to analysed countries

EXPORTS In tonnes												
PARTNER	Bangladesh	China	EU28_EXT	Hong Kong	Indonesia	India	Malaysia	Philipines	Thailand	Turkey	Tawain	Vietnam
PERIOD/PRODUCT	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics
Jan - December 2000	0	4113		118192	171	9498	122	893	332	104	70	0
Jan - December 2001	0	22245		80746	45	4814	0	0	0	20	156	0
Jan - December 2002	0	36588	145883	85313	125	6707	0	124	0	83	47	0
Jan - December 2003	0	108281	253558	115728	83	7140	359	4	138	41	59	0
Jan - December 2004	0	215913	337620	93846	50	7462	1082	0	3	733	2349	142
Jan - December 2005	0	274784	411359	117978	51	293	372	0	0	1213	553	328
Jan - December 2006	0	362127	569383	176844	43	5659	1171	643	0	51	2988	0
Jan - December 2007	0	459027	623228	121696	1	20814	1491	862	317	4002	3253	2609
Jan - December 2008	520	453009	606506	131091	20	7602	2273	0	0	592	2977	2546
Jan - December 2009	9615	736969	1153606	321115	375	20118	12066	44	844	512	6449	15326
Jan - December 2010	9218	657996	1066956	295231	1709	33250	16800	0	1109	5523	3796	9342
Jan - December 2011	300	763342	1089058	228295	2506	37346	15968	0	729	4699	4001	8429
Jan - December 2012	35	799550	1092824	200543	1398	40732	11356	0	145	7871	4399	2854
Jan - December 2013	194	640909	921590	167660	549	37349	35146	0	192	7935	4864	4520
Jan - December 2014	4037	643982	1023787	233532	432	44175	42617	0	556	9509	6540	14326
Jan - December 2015	3896	573949	903885	198791	200	39535	38998	0	20	3461	7347	17584
Jan - December 2016	4849	562788	916589	202032	170	41145	50305	50	192	5445	2517	25531
Jan - December 2017	3035	345814	679723	99193	565	41569	75240	176	2702	16174	1480	69242
Jan - December 2018	3364	13455	499434	72985	64459	67545	131573	434	2045	46945	8175	56779
Jan-19	44	304	44430	7691	10474	5380	10505	75	438	3200	725	2172

Table 4: Imports in Tonnes to Germany from analysed countries

Imports in Tonnes													
PARTNER	Bangladesh	China	EU28_EXT	Hong Kong	Indonesia	India	Malaysia	Philippines	Singapore	Thailand	Turkey	Taiwan	Vietnam
PERIOD/PRODUCT	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915
Jan - December 2000	0	24	0	12	0	4	0	25	11	28	0	66	0
Jan - December 2001	0	0	0	0	0	0	0	0	0	0	100	1	0
Jan - December 2002	0	0	2395	0	0	4	3	0	0	1	34	0	0
Jan - December 2003	0	9	3332	0	0	0	0	0	0	0	0	0	0
Jan - December 2004	0	8	4036	0	0	0	1	0	0	7	0	61	0
Jan - December 2005	0	17	5976	9	0	0	0	0	0	26	1	23	0
Jan - December 2006	0	15	7830	68	0	59	0	80	1	38	25	2	0
Jan - December 2007	0	146	4660	0	0	20	0	0	0	8	9	2	0
Jan - December 2008	4	26	2789	0	0	1	1	21	0	24	72	2	0
Jan - December 2009	0	36	2209	0	0	0	0	0	0	1	0	0	0
Jan - December 2010	0	6	3534	0	0	15	0	0	0	0	79	18	0
Jan - December 2011	0	175	2676	0	0	61	0	0	4	14	452	1	0
Jan - December 2012	54	91	4621	5	1	105	10	0	0	0	40	6	0
Jan - December 2013	108	85	3530	0	0	18	0	0	24	5	0	0	0
Jan - December 2014	16	130	3530	0	6	5	0	0	0	75	126	2	0
Jan - December 2015	0	178	4558	5	0	0	0	0	0	0	42	1	0
Jan - December 2016	0	73	5446	0	0	1	5	0	42	126	29	1	0
Jan - December 2017	0	55	3750	0	5	33	5	0	41	0	39	10	0
Jan - December 2018	21	412	9902	0	24	71	0	0	0	25	92	2	0
201901	0	34	1970	0	0	0	50	0	0	0	33	0	0

Table 5: Exports in Euros from Germany to analysed countries

Exports in Euros													
...	PARTNER	Bangladesh	China	EU28_EXTRA	Hong Kong	Indonesia	India	Malaysia	Philipines	Thailand	Turkey	Tawain	Vietnam
REPORTER	PERIOD/PRODUCT	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics	Waste, Pairings and Scrap of Plastics
DE	Jan - December 2000	€ -	€ 1,107,240.00	€ -	€ 27,424,630.00	€ 29,350.00	€ 2,288,880.00	€ 37,590.00	€ 194,260.00	€ 22,740.00	€ 98,810.00	€ 24,720.00	€ -
DE	Jan - December 2001	€ -	€ 6,151,910.00	€ -	€ 19,781,850.00	€ 8,690.00	€ 1,413,980.00	€ -	€ -	€ -	€ 3,070.00	€ 46,060.00	€ -
DE	Jan - December 2002	€ -	€ 6,689,572.00	€ 32,700,526.00	€ 16,125,179.00	€ 58,000.00	€ 1,688,675.00	€ -	€ 29,635.00	€ -	€ 44,165.00	€ 23,853.00	€ -
DE	Jan - December 2003	€ -	€ 22,227,757.00	€ 56,496,785.00	€ 24,583,464.00	€ 34,684.00	€ 1,527,103.00	€ 88,166.00	€ 1,300.00	€ 59,746.00	€ 25,702.00	€ 22,586.00	€ -
DE	Jan - December 2004	€ -	€ 67,066,526.00	€ 99,616,102.00	€ 24,129,860.00	€ 39,600.00	€ 1,938,319.00	€ 269,654.00	€ -	€ 750.00	€ 316,544.00	€ 746,825.00	€ 37,399.00
DE	Jan - December 2005	€ -	€ 104,651,987.00	€ 148,052,421.00	€ 36,167,685.00	€ 33,500.00	€ 126,833.00	€ 82,908.00	€ -	€ -	€ 753,861.00	€ 210,559.00	€ 40,270.00
DE	Jan - December 2006	€ -	€ 122,051,945.00	€ 180,770,643.00	€ 48,311,227.00	€ 13,175.00	€ 1,231,877.00	€ 259,560.00	€ 196,702.00	€ -	€ 8,204.00	€ 682,413.00	€ -
DE	Jan - December 2007	€ -	€ 152,465,749.00	€ 204,269,891.00	€ 36,047,536.00	€ 1,400.00	€ 9,159,296.00	€ 128,245.00	€ 70,927.00	€ 132,334.00	€ 1,239,030.00	€ 942,734.00	€ 901,201.00
DE	Jan - December 2008	€ 182,279.00	€ 148,755,350.00	€ 190,581,875.00	€ 34,759,651.00	€ 13,000.00	€ 2,739,111.00	€ 296,267.00	€ -	€ -	€ 161,343.00	€ 729,390.00	€ 1,215,228.00
DE	Jan - December 2009	€ 2,448,899.00	€ 175,052,177.00	€ 270,494,003.00	€ 67,220,404.00	€ 121,257.00	€ 5,231,240.00	€ 2,406,278.00	€ 4,940.00	€ 228,545.00	€ 121,561.00	€ 1,106,540.00	€ 3,007,326.00
DE	Jan - December 2010	€ 2,706,649.00	€ 187,683,014.00	€ 301,964,981.00	€ 80,024,550.00	€ 379,088.00	€ 9,181,879.00	€ 3,572,810.00	€ -	€ 159,628.00	€ 1,698,719.00	€ 900,974.00	€ 1,651,226.00
DE	Jan - December 2011	€ 42,827.00	€ 234,426,983.00	€ 344,689,723.00	€ 77,349,412.00	€ 779,967.00	€ 15,231,997.00	€ 3,114,991.00	€ -	€ 202,185.00	€ 2,311,300.00	€ 1,127,692.00	€ 2,173,713.00
DE	Jan - December 2012	€ 4,950.00	€ 272,991,631.00	€ 376,833,709.00	€ 69,887,442.00	€ 535,793.00	€ 17,427,435.00	€ 1,751,656.00	€ -	€ 134,100.00	€ 2,177,489.00	€ 1,122,154.00	€ 798,740.00
DE	Jan - December 2013	€ 111,937.00	€ 230,926,799.00	€ 332,067,948.00	€ 58,671,758.00	€ 92,382.00	€ 18,147,837.00	€ 6,852,188.00	€ -	€ 35,313.00	€ 2,500,495.00	€ 1,220,872.00	€ 1,030,759.00
DE	Jan - December 2014	€ 2,486,592.00	€ 236,605,277.00	€ 365,536,062.00	€ 76,671,762.00	€ 58,680.00	€ 22,074,114.00	€ 8,268,391.00	€ -	€ 85,954.00	€ 3,036,101.00	€ 1,807,746.00	€ 3,308,872.00
DE	Jan - December 2015	€ 2,157,785.00	€ 198,542,225.00	€ 311,303,215.00	€ 66,870,179.00	€ 108,368.00	€ 20,609,342.00	€ 6,937,808.00	€ -	€ 6,916.00	€ 1,120,677.00	€ 2,219,453.00	€ 4,986,649.00
DE	Jan - December 2016	€ 2,257,418.00	€ 166,094,493.00	€ 262,507,763.00	€ 54,081,825.00	€ 69,040.00	€ 19,127,132.00	€ 6,399,829.00	€ 11,980.00	€ 43,500.00	€ 1,498,252.00	€ 608,863.00	€ 5,641,279.00
DE	Jan - December 2017	€ 1,327,682.00	€ 109,542,366.00	€ 195,647,236.00	€ 31,945,476.00	€ 73,555.00	€ 15,711,038.00	€ 10,217,360.00	€ 7,000.00	€ 698,918.00	€ 3,845,869.00	€ 293,438.00	€ 16,320,660.00
DE	Jan - December 2018	€ 932,089.00	€ 5,667,384.00	€ 119,760,093.00	€ 25,564,462.00	€ 12,638,555.00	€ 16,889,413.00	€ 24,033,965.00	€ 139,165.00	€ 507,477.00	€ 7,865,766.00	€ 2,122,399.00	€ 13,129,608.00
DE	Jan-19	€ 5,803.00	€ 94,630.00	€ 11,117,436.00	€ 2,037,873.00	€ 2,452,555.00	€ 1,466,367.00	€ 2,084,229.00	€ 11,232.00	€ 63,806.00	€ 503,282.00	€ 230,865.00	€ 467,600.00

Table 6: Imports in Euros to Germany from analysed countries

Imports in Euros													
...	PARTNER	Bangladesh	China	EU28_EXTRA	Hong Kong	Indonesia	India	Malaysia	Philipines	Thailand	Turkey	Taiwan	Vietnam
REPORTER	PERIOD/PRODUCT	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915	3915
DE	Jan - December 2000	€ -	€ 22,640.00	€ -	€ 1,100.00	€ -	€ 9,660.00	€ 1,290.00	€ 7,140.00	€ 10,660.00	€ -	€ 23,730.00	€ -
DE	Jan - December 2001	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ 38,400.00	€ 4,600.00	€ -
DE	Jan - December 2002	€ -	€ 647.00	€ 705,807.00	€ -	€ -	€ 10,462.00	€ 4,057.00	€ -	€ 1,141.00	€ 15,014.00	€ 739.00	€ -
DE	Jan - December 2003	€ -	€ 25,206.00	€ 533,068.00	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
DE	Jan - December 2004	€ -	€ 19,589.00	€ 733,495.00	€ -	€ -	€ -	€ 772.00	€ -	€ 5,385.00	€ -	€ 80,085.00	€ -
DE	Jan - December 2005	€ -	€ 6,309.00	€ 807,826.00	€ 732.00	€ -	€ -	€ -	€ -	€ 11,822.00	€ 660.00	€ 4,418.00	€ -
DE	Jan - December 2006	€ -	€ 23,049.00	€ 1,799,624.00	€ 38,713.00	€ -	€ 39,563.00	€ -	€ 60,102.00	€ 32,593.00	€ 11,535.00	€ 22,039.00	€ -
DE	Jan - December 2007	€ -	€ 59,820.00	€ 1,724,539.00	€ -	€ -	€ 7,613.00	€ -	€ -	€ 9,517.00	€ 6,286.00	€ 10,245.00	€ -
DE	Jan - December 2008	€ 2,438.00	€ 48,064.00	€ 1,579,794.00	€ -	€ -	€ 4,449.00	€ 2,096.00	€ 13,860.00	€ 19,002.00	€ 63,506.00	€ 20,451.00	€ -
DE	Jan - December 2009	€ -	€ 13,564.00	€ 927,887.00	€ -	€ -	€ -	€ -	€ -	€ 2,100.00	€ -	€ -	€ -
DE	Jan - December 2010	€ -	€ 12,267.00	€ 1,711,780.00	€ -	€ -	€ 9,239.00	€ -	€ -	€ -	€ 14,595.00	€ 19,316.00	€ -
DE	Jan - December 2011	€ -	€ 181,544.00	€ 1,818,170.00	€ -	€ -	€ 25,954.00	€ -	€ -	€ 7,830.00	€ 376,377.00	€ 354.00	€ -
DE	Jan - December 2012	€ 14,633.00	€ 74,539.00	€ 2,393,463.00	€ 23,909.00	€ 2,311.00	€ 28,257.00	€ 7,476.00	€ -	€ -	€ 37,575.00	€ 15,161.00	€ -
DE	Jan - December 2013	€ 29,786.00	€ 37,251.00	€ 1,198,877.00	€ -	€ -	€ 5,331.00	€ -	€ -	€ 3,247.00	€ -	€ -	€ -
DE	Jan - December 2014	€ 5,323.00	€ 38,483.00	€ 1,146,375.00	€ -	€ 1,636.00	€ 3,114.00	€ -	€ -	€ 14,285.00	€ 108,553.00	€ 2,530.00	€ -
DE	Jan - December 2015	€ -	€ 57,697.00	€ 1,691,772.00	€ 1,282.00	€ -	€ -	€ -	€ -	€ -	€ 5,209.00	€ 1,095.00	€ -
DE	Jan - December 2016	€ -	€ 89,001.00	€ 2,340,465.00	€ -	€ -	€ 651.00	€ 7,340.00	€ -	€ 105,618.00	€ 2,540.00	€ 1,593.00	€ -
DE	Jan - December 2017	€ -	€ 20,308.00	€ 1,961,388.00	€ -	€ 1,290.00	€ 12,766.00	€ 6,150.00	€ -	€ -	€ 46,887.00	€ 6,268.00	€ -
DE	Jan - December 2018	€ 11,294.00	€ 151,727.00	€ 4,833,670.00	€ -	€ 19,373.00	€ 29,651.00	€ -	€ -	€ 14,447.00	€ 4,389.00	€ 220.00	€ -
DE	Jan-19	€ -	€ 6,481.00	€ 1,016,729.00	€ -	€ -	€ -	€ 37,732.00	€ -	€ -	€ 21,610.00	€ -	€ -