



Universiteit Utrecht

Master Thesis:

Non-profit Organizations as Developers and Drivers of Innovation:
An Exploration of the Googly-eyed Garbage Gobbler

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Abstract

Within the innovation systems literature, non-profit organizations (NPOs) are known contributors to the spread of novel products and services. However, while non-profits as intermediaries have been thoroughly explored, non-profits as innovation developers have received less attention and what distinguishes them from other entrepreneurial actors has not been addressed. Therefore, this research takes an exploratory route by looking into an influential actor within the environmental water clean-up technology sector, the Waterfront Partnership of Baltimore (WPB), to answer the following question: *How was WPB able to drive innovation within the environmental water clean-up technological sector, and what can we learn about NPOs' innovation system strengthening potential in general?*

By conducting documentation reviews and interviews, this research was able to determine how WPB contributed to the strengthening of innovation system functions in ways that other actors within the same system could not. This research found that WPB was able to drive the system by (1) filling gaps left by public and private actors, (2) utilizing advantages available to NPOs, (3) exploiting synergies from NPO collaboration with for-profit actors and (4) solving the trash problem by simultaneously pushing the TrashWheel technology and investing in other approaches to reduce the need for this type of technology. From this research, a broader understanding of non-profit potential within innovation systems and NPO roles are explored. NPOs interested in innovation, or those organisations that wish to collaborate with a NPO, can better understand details such as: the gap in capabilities and interest left by other types of entrepreneurial actors, the financial tools and trust that can give NPOs an advantage, the benefits of a symbiotic relationship with a for-profit actor and how to pursue multiple approaches for solving meta-level problems.

1. Introduction

Non-profit organizations (NPOs) are organizations that further a particular societal cause or advocate a shared point of view (LII, n.d.). They are tax-exempt or charitable and are identified as part of the voluntary sector; a sector that lies between the public and private sectors (Zimmermann, 1999).¹ In most countries around the world, the expansion of their non-profit sectors has been impossible to ignore. Over the last few decades, the activity and influence of NPOs in most countries has grown exponentially (Casey, 2016). Take the U.S. for example. From 2007 to 2016 the non-profit sector increased by 16.7% and when treated as a single ‘industry’, the non-profit sector is the third largest employer (Trull, 2019). Moreover, the biggest NPOs have gotten bigger and non-profits overall are growing bigger at a faster rate (Kim & Bradach, 2012). As these non-profit sectors and organizations continue to grow, so does their relevance.

In addition to their increasing economic role, NPOs have long held a vital role within the innovation system (Khallouk & Robert, 2018). Since NPOs cover the gap between the private and public sectors, they can often act as critical intermediaries (Berrone et al. 2013). The supporting roles of *intermediary NPOs (here: iNPOs)* include, but are not limited to; creating legitimacy, assisting in innovation framing, providing knowledge and encouragement, and helping to generate unique and disruptive ideas with the private sector (Berrone et al. 2013). NPOs can also be sources of innovation themselves (Zimmermann, 1999). Since NPOs can face challenges with “financial fuzziness” (i.e. inconsistent or limited funding and resources which can result in critical program cuts, scrambles for financial support and inefficient monetary flows), many NPOs find themselves in a position where they need to develop efficient and effective solutions to conserve resources (Foster, et al., 2009; Blankenburg, 2018; Jaskyte et al., 2018). NPOs can also act as innovation champions that support innovations by providing idea identification, perseverance, connecting and influencing (Molloy et al., 2020). Furthermore, NPOs are viewed as innovative by nature, since they can create solutions to resolve community problems that are the sole targets of their organizational missions and operate within the vacuum of innovation left by the public and private sectors (Cnaan & Vinokur-Kaplan, 2014; Berrone et al. 2013).

Though the literature covering the supporting roles of intermediary NPOs in innovation systems is substantial, there is only a small body of research covering what we might call *innovation developing NPOs (IDNPOs)* as sources of innovation in their own right. One of the scarce studies on this matter found that NPOs that pursue both technological and non-technological innovations had a sustained competitive advantage against other NPOs and

¹ What defines NPOs and non-governmental organizations (NGOs) can overlap and most NGOs are NPOs (BD, 2019). The laws that qualify organizations as NPOs or NGOs differ per country; in some countries, they are one and the same (CMU, n.d.). Here, we will define NPOs as NPOs or NGOs in which any surplus of revenue is used to further the NPOs ultimate objective rather than pay off shareholders, leaders, or members (LII, n.d.). This covers organizations whose start-up funding is provided by their members, trustees, or others who do not expect repayment and who do not share in the organization’s profits or losses (BD, 2019). Also note that NFP is another term for NPO within innovation literature.

commercial organizations (Weerawardena and Sullivan-mort, 2001). Current literature also gives some insight into the innovative behavior of IDNPOs, innovation barriers that IDNPOs encounter, and other aspects (e.g. the role of power within IDNPOs, marketing strategies) that can affect innovation within IDNPOs. It contains research on how a clear, motivating organizational mission allows IDNPOs to be more innovative (McDonald, 2007). Additionally, it delves into the breakthrough and development of service, organizational, social, and managerial innovations within IDNPOs. Therefore, in order to build upon this knowledge and focus on IDNPOs, this research intends to look beyond the use of novelties by NPOs. This seems a caveat, as NPOs allegedly can do more than helping other parties to innovate.

Take the The Ocean Cleanup (TOC) for example, a NPO that has been observed spearheading the largest scale ocean clean-up effort in order to rid the ocean of plastic waste. In order to accomplish their organizational mission, TOC has developed and forged a way for their passive ocean clean-up technology, named Wilson, to gather ocean plastic more efficiently (The Ocean Cleanup, 2019). TOC's development of Wilson and its resulting contributions to the innovation system as an IDNPO extend beyond what is explained by current literature in two ways. Firstly, though NPOs can be sources of innovation, the types of innovations that IDNPOs are known sources of (e.g. managerial, organizational, social) are generally the result of the NPOs' "financial fuzziness": having to develop more efficient ways to conserve resources, find a way to solve a problem on a budget or to find a way to gather more resources to fund their mission (Hull & Lio, 2006). On top of that, meeting expectations and performance measurements to maintain consistent cash flows can limit an NPO's ability to partake in risky activities (Hull & Lio, 2006). These are not favorable conditions for providing the type of environment needed to develop technological innovations. Yet the *technological innovations* of NPOs like Wilson - that can require large, long-term and resource intensive investments - are observed to exist (Troilo et al. 2013). Secondly, how IDNPOs, like TOC, *drive and shape technological innovation systems* with their activities surrounding the development of their technological innovation is unknown. As previously mentioned, there is plenty of research covering the system contributions of iNPOs (Berrone et al. 2013) and newer research covering NPOs as champions (Molloy et al., 2020). However, the literature review did not reveal the system contributions of IDNPOs in relation to their respective innovations. Therefore, to begin building a perspective of possible NPO system contribution capabilities, we need to understand how direct NPO involvement in innovation development adds to known intermediary system contributions to influence the system.

An initial preliminary search turned up only a handful of cases globally where IDNPOs have developed technological innovations and even fewer who were willing to participate in this research. Therefore, this research intends to focus on a single case, the Waterfront Partnership of Baltimore (*WPB*), and take on an exploratory route in its collaboration with Clearwater Mills (*CM*) to develop the TrashWheel. It will try to have an understanding of how the WPB was able to drive innovation and what made its role and involvement as an NPO unique. This includes looking into what challenges WPB overcame, what opportunities were at hand, what NPO characteristics they have to give them the advantage and how the collaboration contributed to the development of the TrashWheel and how this allowed them to

shape the system as a result. The aim of this study is to understand what WPB might have done different, to set it apart. What insights can be gained in how they innovate? By looking into these factors, this research can look into how an IDNPOs can contribute to the strengthening of technological innovation systems around solutions addressing the societal problem a NPO is pursuing. Therefore, this research intends to answer the following research question:

How was WPB able to drive innovation within the environmental water clean-up technological sector, and what can we learn about NPOs' innovation system strengthening potential in general?

This research intends to incorporate a single, in-depth case study of one NPO that has been observed to be a critical actor in its system. How it contributed to the innovation system will be analyzed in order to address the research question. This involves mapping what system activities they took part in and understanding how they tie into the observations of how WPB was able to contribute. By doing this, NPO potential in technological innovations systems can be explored. The case study research will be guided by a conceptual model integrating several concepts from innovation (systems) theory, in order to address the research question and to better understand the relation between NPOs, technological innovation and innovation systems.

For the single case study, a NPO from the domain of environmental water clean-up (EWCU) NPOs has been chosen since NPOs in this domain are assumed to have more direct roles in technological innovation because they are (1) generally not covered by for-profit or governmental entities, since they are seen as not profitable, investment intensive and risky, and (2) the societal problem could benefit from an innovative technical solution (Clarke, et al., 1994; Ozusaglam, 2012). EWCU NPOs are NPOs whose missions and efforts are directed towards cleaning-up the environment. The efforts of EWCU NPOs blanket many different types of activities, ranging from the coordination of voluntary trash pickup events to bringing public attention and shame to companies that contribute to dumping and environmental pollution (Eisenhauer, 2017).

1.1 Theoretical and Practical Contributions

From a theoretical standpoint, the goal of this research is to continue to unravel NPO involvement in innovation systems. It will provide a basis for future research into this area by establishing that NPOs play more than just support roles within a system. Not only will there be a better overall understanding of IDNPO contribution, but we can begin to understand an actual observed case that exists within current innovation systems. Additionally, this research will develop a novel conceptual framework needed to provide a way to assess and understand the extent of NPO involvement and contribution to driving forward, shaping and supporting innovation systems.

This research also aims to provide support for practical application. It can help other actors in innovation systems, including policy makers and financiers, with better understanding

the potential of NPO contributions to innovation system strengthening. By understanding this and the uniqueness that NPOs can bring to innovation, other actors can more effectively determine how they want to work with NPOs and how they can best support or benefit from the work that NPOs do within collective efforts to steer and accelerate innovation. Furthermore, NPOs can better understand what other roles, in addition to supportive, they can have to achieve their mission and in what ways they can overcome challenges that they might encounter and what opportunities can be seized.

2. Theory

This section introduces the theories and concepts that are built upon in order to understand the innovation dynamics NPOs might be part of. Theoretical insights on this matter are obtained from the literature on technological innovation systems (Section 2.1.1), combined with research on the activities and potential of NPOs as intermediaries (Section 2.1.2). In Section 2.2 the relevant concepts from these branches of research will be linked together in one comprehensive theoretical framework.

2.1 Theoretical Background

2.1.1 NPOs as Intermediaries

Intermediaries are important to innovation, as they act as the middleman. There are three types of intermediaries that contribute to innovation: hard, soft and systemic (van Lente et al., 2003). Each has a different set of contribution characteristics and supports and strengthens innovation at different levels. For this research, systemic innovation intermediaries are of particular interest since they function at the system and network level (van Lente et al., 2003). In innovation systems, co-operation is needed for knowledge exchange and successful innovation. Therefore, systemic intermediary organizations are needed to fill systemic gaps that lead to system failures by acting as brokers in the formation and maintenance of innovation systems (Klerkx and Leeuwis, 2009). Hence, intermediaries contribute to several of the innovation systems functions defined in Hekkert et al.'s 2007 paper (Klerkx and Leeuwis, 2009).

In understanding what functions systemic intermediary organizations can fulfil, a paper by Kilelu et al. (2011) compiles a comprehensive list from the current literature of systemic innovation intermediary functions. Hannon further visualizes these six broad functions and their relative activities in Table 2.1.1a (below).

| Function | Related activities | Sub-activities |
|--|--------------------------------------|--|
| Demand articulation | Scanning and scoping | Gathering information |
| | | Identify opportunities |
| | Foresight | Strategic planning |
| | | Visioning |
| | | Brainstorming |
| | Diagnosis | Needs assessment |
| Knowledge gaps assessment | | |
| Demand stimulation | | |
| Network building | Gate keeping | Filtering |
| | | Selecting collaborators |
| | Match making | Linking and coordinating |
| | | Forming partnerships |
| Capacity building | Organisation development | Initiating organisations |
| | | Organisations/group dynamics management |
| | | Incubating enterprises |
| | Training and competence building | Managerial skills |
| | | Certification/standards |
| | | Technical skills |
| Innovation process management | Mediating and arbitrating | Managing conflict |
| | | Negotiating |
| | | Interface management |
| | Learning | Providing space/platforms |
| Aligning agendas | Building trust | |
| Knowledge brokering | Disseminating knowledge | Transferring |
| | | Advising |
| | | Informing |
| | Communicating knowledge | Experimenting |
| | | Peer exchange |
| | | Demonstrating |
| | Matching knowledge demand and supply | Sourcing |
| Articulating experiential/indigenous knowledge | | |
| Institutional support | Boundary work | Interfacing science and practice |
| | | Platform for policy advocacy |
| | Institutional change | Facilitating changes in rules/regulation |
| | | Working on attitudes and practice |

Table 2.1.1a Six systemic innovation intermediary functions and their associated activities and sub-activities (Hannon, 2016)

When reviewing the literature covering NPO-specific involvement as intermediaries in technological innovation, iNPOs were found to contribute to the six systemic intermediary functions listed in Table 2.1.1a (above) in a variety of ways. A sample of papers listing specific iNPO contributions to the six functions are presented below (Table 2.1.1b) to give examples:

| Paper | iNPO contributions |
|----------------------|---|
| Berrone et al., 2013 | Exercising their voice; channeling and coordinating activist groups; social movement initiatives; help build legitimacy (e.g. creating voluntary standard for firms, engaging firms in long term commitments to |

| | |
|------------------------|---|
| | help build repour); sources of new ideas; sources of knowledge for new and disruptive ideas; provide resources and consultation |
| Zimmerman, 1999 | Supporting laws by creating watchdog groups; lobbying to create or challenge laws |
| Klerkx & Leeuwis, 2009 | Demand articulation; network composition; scanning, scoping, filtering and matchmaking; innovation process management; research planning; creation of legitimacy; resource provider for resource mobilization; assist in network formation for knowledge diffusion; |
| Holmes & Smart, 2009 | Help build innovation capacity and capabilities (e.g. pooling their knowledge and skills with other organizations); facilitates collaboration and interactions to support innovation |
| Jaskyte & Lee, 2006 | Facilitating the combination and coordination of resources, information, technical assistance and work |

Table 2.1.1b Examples of specific iNPO contributions from research papers

With the list of intermediary functions, activities, sub-activities and examples of known iNPO contributions, this research lays out the known ways in which NPOs help support TIS functions and the gaps that they fill. It is important that there is a clear distinction between what this research intends to do and previous research to better understand the full scope of NPOs in the context of TISs. This research intends to show in what ways NPOs can directly contribute to or fulfil TIS functions as developers of innovation, in combination with or in place of just acting as intermediaries in TIS function support. That NPOs can also drive forward and shape TISs instead of just supporting and strengthening them.

2.1.2 NPOs as Drivers in Technological Innovation Systems

There is little literature covering IDNPOs specifically, and the literature that does exist is sparse and fragmented across several different types of innovation theories. In terms of IDNPO literature within the innovation system branch of theories, there was little to base this research of off. The assumption is that IDNPOs are lumped in under the general tab of TIS innovators and are therefore, indistinguishable from other types of entrepreneurs within the system. However, because NPOs have fundamental differences that differentiate them from other types of organizations, it can be intuitively reasoned that there are key differences that distinguish them from other types of innovative entrepreneurs within innovation systems (Hull & Lio, 2006). This includes how they might influence and shape a system.

A systems approach to innovation involves applying an analytical construct to help understand the processes underlying innovation and its infrastructure (Bergek et al., 2008). These innovation systems are composed of networks of actors and institutions that develop, diffuse, and use innovations (Markard and Truffer, 2008). Specifically, technological innovation systems (TIS) focus on a particular technology and include the knowledge around a product as well as the product itself (Bergek et al., 2008). The structural part of a TIS is composed of a set of structural elements; including technologies actors, networks and institutions, which actively contribute to the development of that technological field (Bergek et al., 2015). Additionally, TIS perspectives emphasize the system boundaries and infrastructure (Bergek et al., 2015).

Not only are the actors and institutions that structure TISs important, but so are the interactions between them (Bergek et al., 2008). A seminal paper by Hekkert et al. (2007) outlines seven key functions that provide insight into the dynamics and interactions of innovation systems (as seen in Table 2.1.2 below). The development of systems determined by function fulfilment is key.

| Key process | Description |
|----------------------------------|--|
| Experimentation by entrepreneurs | Entrepreneurs are essential for a well functioning innovation system. Their role is to turn the potential of new knowledge, networks, and markets into concrete actions to generate—and take advantage of—new business opportunities. |
| Knowledge development | Mechanisms of learning are at the heart of any innovation process, where knowledge is a fundamental resource. Therefore, knowledge development is a crucial part of innovation systems. |
| Knowledge exchange | To learn relevant knowledge needs to be exchanged between actors in the system. |
| Guidance of the search | This system function refers to those processes that lead to a clear development goal for the new technology based on technological expectations, articulated user demand and societal discourse. This process enables selection, which guides the distribution of resources. |
| Market formation | This process refers to the creation of markets for the new technology. In early phases of developments these can be small niche markets but later a larger market is needed to facilitate cost reduction and incentives for entrepreneurs to move in. |
| Resource mobilisation | The financial, human and physical resources are necessary basic inputs for all activities in the innovation system. Without these resources, other processes are hampered. |
| Creation of legitimacy | Innovation is by definition uncertain. A certain level of legitimacy is required for actors to commit to the new technology with investment, adoption decisions, etc. |

Table 2.1.2 List of the TIS key functions and their descriptions (Wieczorek et al., 2013)

Since TISs are analytical constructs, they can be used as a tool to better understand system dynamics and performance and allow us to map out systems for analysis (Bergek, et al., 2008; Hekkert et al., 2007). Measurement techniques have also been developed on how to breakdown and analyze the statuses of each key process in order to provide an evaluation of the overall system (Hillman et al., 2011). From these studies, we are able to conduct impact assessments by assessing the breakdown of contributions to the system (Janssen, 2019). Though many things can impact a system, such as programs, policy, and projects; actors specifically are able to strategically influence system elements when impacting a TIS (Musiolik

& Markard, 2011). Therefore, this research will follow precedent by utilizing an innovation system analyses as an evaluative tool to conduct an impact assessment and determine the contributions made and overall influence that IDNPOs have on a TIS.

The innovation systems theory provides the premise needed for evaluating how an NPO engages in technological innovation within the broader scope of its involvement a TIS. It provides a mapping tool for investigating structural positioning and which key processes NPOs are involved in and their system dynamics. By completing a partial mapping of WPB within its TIS, it can be determined how an NPO can contribute to the TIS; whether it provides support or actually drives the TIS forward by influencing the development of a TIS framework. Furthermore, it also allows this research to tie these key processes to the uniqueness that NPOs can bring to the innovation process with the system environment.

2.2 Theoretical Framework

The theoretical framework, shown in Figure 2.2 below, merges the previously discussed theories covered in Section 2.1 in order to provide a basis for this research. By combining these pieces, a broader understanding of the critical contributions that a NPO can make to a TIS can be laid out. The figure shows (1) the direct contributions that can be made to the structure of a TIS through its functions and (2) the intermediary contributions that can be made to support the system by filling system gaps and preventing system failures. This research intends for focus on (1) the direct contributions, because there are observations of NPOs as developers of technological innovations, activities that in themselves go beyond the realm of intermediary functions and spill into what into is defined by TIS functions. Therefore, this research needs to be able to map what TIS functions IDNPOs are observed contributing to and how they contribute to them in ways other actors cannot. This will provide the overall picture with a more detailed sense of NPO's involvement in the system and a way to map an IDNPO's contribution to TIS functions.

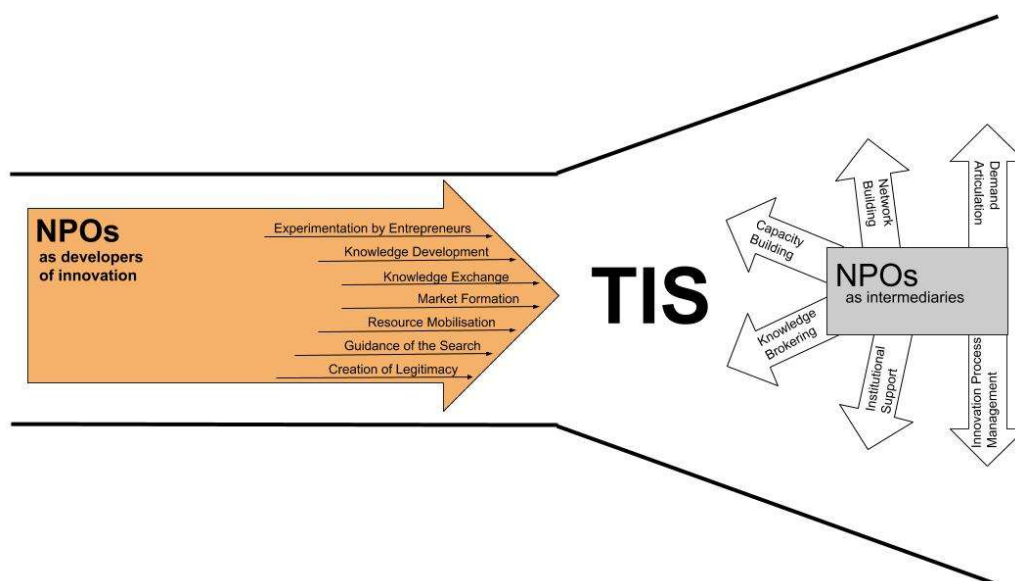


Figure 2.2 Theoretical framework overview

As developers of innovation, IDNPOs contribute to a TIS by becoming one of the actors that the TIS structure is comprised of. These NPOs can drive forward or shape the TIS by directly contributing to its functions. This influence of IDNPOs is depicted in Figure 2.2 (above) by the orange arrow and is what this study will be focusing on. By mapping out the activities of these IDNPOs and how these activities contribute to the seven system functions, this research can get a comprehensive grasp of how involved NPOs are in TISs and to what extent and in what ways IDNPOs are capable of influencing a TIS. It will direct this research towards the research question and help to close the identified literature gap.

As intermediaries, NPOs support a TIS by filling in gaps and strengthening the system to prevent it from collapsing. This is represented in Figure 2.2 by the grey box and its supporting arrows. Though this research will not be focusing on iNPOs, the comprehensive overview of all possible functions and activities that NPOs could contribute to as intermediaries is listed, as well as the functions and activities that iNPOs have already been observed contributing are listed in Section 2.1.1.

Overall, Figure 2.2 shows the two different ways in which NPOs are assumed to contribute to a TIS: as developers of innovation (IDNPOs) and as intermediaries (iNPOs). The IDNPOs contribute to the system functions, which gives them the possibility of influencing a TIS's structure, and the iNPOs contribute to the intermediary functions, which allows them to support the system structure. By utilizing this theoretical framework, which consists of the possible functions and processes that a NPO can contribute to, the activities around a NPO's technological innovation can be mapped out. Therefore, we can better understand the actual activities that NPOs do and fulfill to determine what system functions and processes they contribute to in practice. Additionally, we can then evaluate how NPOs are able to directly contribute to these system functions and in what way this differentiates them from other types of developers of innovation. As a result, a more complete picture of how NPOs contribute to TISs is provided.

3. Methodology

For this methodology section, the case selection, type of methods and how the methods themselves were conducted for this research will be explained.

3.1 Overall Research Design

This research intends to use a qualitative approach for a single-case exploratory study. A single-case study will allow this research to conduct an exploratory case study aimed at building an initial understanding of IDNPOs within a TIS to provide a basis for future research, since the current theory does not make this clear (Lazar et al., 2017). A qualitative approach utilizing interviews will allow this research to understand how the case contributes to driving the TIS and to address the research question in order to understand what IDNPOs contribute to the system that differentiates them from other types of innovation developers. Additionally, this research will utilize an inductive analysis approach to derive how the IDNPO is able to contribute to these activities and functions by exploring why an IDNPO was needed, what opportunities the IDNPO made use of and what challenges needed to be overcome (Patton, 2002). A timeline of the case will also be constructed to provide a time-dimensional aspect to this research to support and help visualize the significance of the TIS function contributions.

3.2 Preliminary Research

During the preliminary research phase of this research, which was needed to scope out the landscape and for case selection, there were several notable observations of IDNPOs made. It was found that news articles from Google (a universal search engine) and LexusNexus (an international news database) and NPO websites contained a wealth of information. NPOs and their innovations are a very newsworthy topic and several IDNPOs from various industries and sectors had thorough news coverage. Though the coverage per IDNPO varies and there was some inconsistent coverage of smaller IDNPOs between news sources, there was a plethora of information to work with between the archived news articles and the NPO websites themselves.

3.3 Case Selection

For this research, the case selection focused on NPOs that were:

- (1) the, or one of the, main developers of a technological innovation and
- (2) operate in the EWCUT domain

First, a partial mapping of all the entrepreneurial actors was completed by utilizing the information uncovered in the preliminary research and an environmental water clean-up technology (EWCUT) sector timeline depicting the emergence of all the different technologies within this sector was constructed, as seen in Figure 3.3, below.

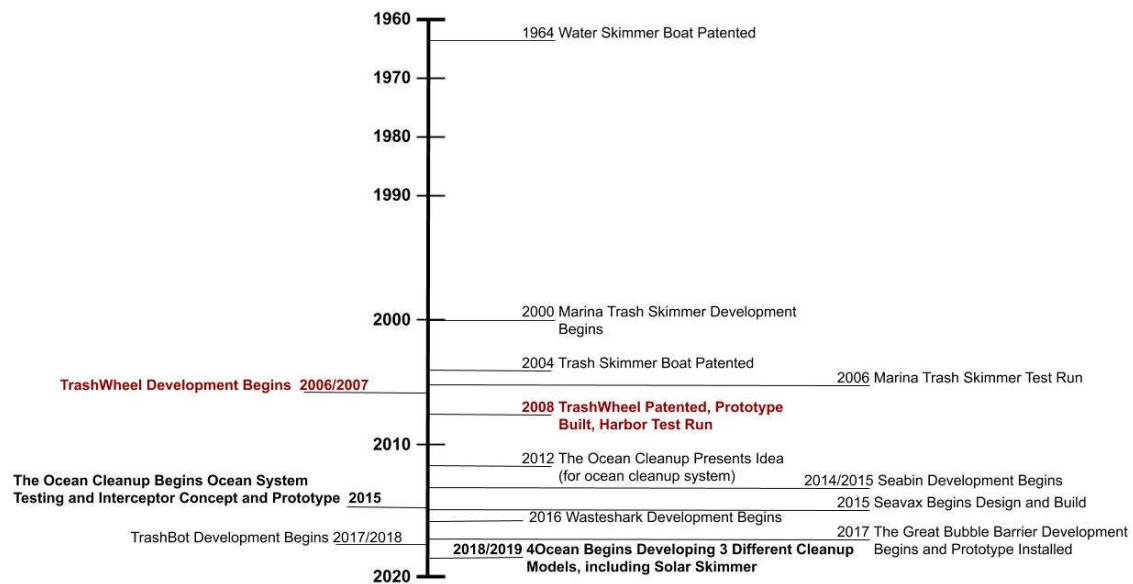


Figure 3.3 EWCUT Sector Timeline (Dunkerly, 1966; Clean Ocean Access, N/A; Walczyk, 2006; Kraimer et al., N/A; The Ocean Cleanup, 2019; Seabin Project, 2020; Bluebird Energy Systems, 2020; Port of Rotterdam Authority, 2016; The Great Bubble Barrier, 2019; Urban Rivers, N/A; 4ocean, N/A)

Since the purpose of this research is to understand IDNPOs that drive the innovation within this sector, the goal of this research was to then select a case with a strong influence on the TIS that met the aforementioned criteria.

The TrashWheel (shown in bold red in Figure 3.3) is notable because it is the second technology, behind the Marina Trash Skimmer, to run autonomously and the first to be energy neutral. Instead of running off diesel engines and motors like its predecessors, it runs solely off solar and hydro renewable energy. Energy neutral technology becomes a more common occurrence after the TrashWheel's debut, with The Ocean Cleanup's Ocean System, Interceptor, Seavax and 4Ocean Solar Skimmer all following suite. It was also the first to be stationed at a river/inlet, where studies later found most of the trash flows in from, as trash is mostly land-based (Sherrington, 2016). Furthermore, there are two cases of imitation (shown in bold in Figure 3.3) that are seemingly based off of the TrashWheel, making it the most imitated technology within this sector to-date. The first case being the already deployed Interceptor, by The Ocean Cleanup, and the second being the Solar Skimmer by 4Ocean, which is still in development. Together with the TrashWheel, these are the only three EWCUTs that tackle trash flowing through rivers and inlets, meaning that the TrashWheel has set the precedent for EWCUTs made for rivers and inlets and is the dominant technology for this type of cleanup. These observations give a first indication that TrashWheel had a hand in shaping this sector and the technologies within it. Therefore, the TrashWheel, which was developed by the Waterfront Partnership of Baltimore and Clearwater Mills, was selected as the single-case for this study as it was found to have a strong influence on the TIS.

3.4 Operationalization

In order to understand how WPB drives the development of technological innovation within the EWCU TIS, this research must be broken down into steps. Firstly, this research needs to understand why a NPO was needed to fully develop the innovation and what differentiated it in this regard from other actors. This will be done by understanding what activities other actors were unable to fulfil, why they were unable to fulfil them and how WPB was able to fulfil these activities. The activities that the WPB is involved in that allowed them to overcome challenges and take on opportunities within the system will also need to be investigated. Secondly, this research will need to link each of the activities found for WPB to their respective system function to provide an in-depth understanding and context on how IDNPO's activities contribute to each system process and drive the overall system.

| Variables | What to Assess | Questions to Assess |
|-------------------------------------|---|---|
| Activity Gap | Limitations of other organizations' system contributions and why these limitations exist | <ul style="list-style-type: none"> - Do you think (name of organization) would have been able to fully develop the TrashWheel? If not, why not? If yes, why didn't they? - Why did (name of organization) not collaborate with CM and help fully develop the TrashWheel? - What do you think WPB was able to do that (name of organization) was not? |
| WPB Activity Contribution | WPB's system contributions and why they were able to make these contributions | <ul style="list-style-type: none"> - What was WPB able to do that other organizations were not able to do? - Why was WPB suitable for developing the TrashWheel? - What did WPB have to be able to develop the TrashWheel that other actors did not? - What is needed to develop an innovation like the TrashWheel? |
| Activities to Address Challenges | Presence/absence of challenges If present: What was the challenge? How was it overcome? | <ul style="list-style-type: none"> - Did you experience challenges while developing the TrashWheel innovation? - What were these challenges? - When was this challenge experienced? - How was in overcome? - Did something else contribute to overcoming this challenge? |
| Activities to Address Opportunities | Presence/absence of opportunities If present: What was the opportunity? How was it seized? | <ul style="list-style-type: none"> - Did you experience opportunities during the innovation process? - Did you experience opportunities in your interactions with governments, companies, or any partners/collaborators? - When did you experience each opportunity? |

| Variable | What to Assess | Questions to Assess |
|----------------------------|--|---|
| WPB's System Impact | Which TIS function does a certain activity strengthen? | <ul style="list-style-type: none"> - What activity does this impact relate to? - Does this activity impact: (F1) Entrepreneurial Activities, (F2) Knowledge Development, (F3) Knowledge Diffusion, (F4) Guidance of the Search, (F5) Market Formation, (F6) Resource Mobilization or (F7) Creation of Legitimacy? |
| Limitation of Other Actors | Which TIS function did this limitation effect? | <ul style="list-style-type: none"> - What activity does this limitation relate to? - Did this lack of activity leave a gap in (F1) Entrepreneurial Activities, (F2) Knowledge Development, (F3) Knowledge Diffusion, (F4) Guidance of the Search, (F5) Market Formation, (F6) Resource Mobilization or (F7) Creation of Legitimacy? |

3.5 Data Collection

The data collection of this research will be done in two parts; first by documentation review and then by interviews.

3.5.1 Documentation Review

As previously mentioned in Section 3.2, the preliminary research indicated that there was enough information coverage to begin with a documentation review. This research will evaluate the following for WPB: news articles from archives, the NPO's website, interview transcripts and any other types of documentation covering information around WPB's involvement in the TrashWheel. These documents will be reviewed for general information surrounding WPB's involvement in the TrashWheel's development, as well as for any additional information needed to map out the WPB's contributions to the TIS functions and overall system. The intention of this documentation review is to build a knowledge base to provide a basis, supplement and support the more in-depth information that will be collected from the interviews.

3.5.2 Interviews

The interviews will build upon the documentation review and be conducted to ascertain additional details, more in-depth information, actor perspectives and additional system activities surrounding WPB's involvement in the system. These will lead to the final information gathering around the need for WPB's involvement as well as how suitable they were to take on challenges and opportunities within this sector.

The interviews will consist of interviewees from WPB, their co-developer and other actors within WPB's direct network.

1. For the WPB and their co-developer, CM, the target group for these interviews will consist of: employees of WPB and CM that have authority over or extensive

- knowledge about the WPB's activities around the TrashWheel development within the innovation system.
2. For the stakeholders and partners within WPB's direct network, the interviewees will consist of: employees of these actors that have direct authority over or extensive knowledge about the actor's activities with WPM
 3. For individual actors within WPB's direct network, the interviewees will consist of: individuals that directly engages with WPB and has extensive knowledge about the overall network and system.

These interviews will be done in two rounds. By separating it into two rounds, the researcher will be able to get an overall picture before focusing, in detail, on interesting observations and specific topics around WPB's activities. The first round of interviews will assess the activities of each actor around the TrashWheel. More specifically, the first interviews with WPB and CM will focus on what activities they took part in to take on challenges and opportunities and what other contributions and activities around the TrashWheel each was involved in. For the first round of interviews with stakeholders and partners, the interviews will focus on their organization's contributions to and activities around the TrashWheel as well as their perspective and knowledge around WPB's contributions to the TIS.

The second round of interviews will gather information on how and why WPB was about to fully develop the TrashWheel within the system and the limitations of other actors that have benefitted from this technology. For WPB and CM, these interviews focus on their collaboration, the reason for their involvement in the TrashWheel, what they perceived was missing from the system and how and why they were able to contribute to the TIS in ways that others could not. For stakeholders and partners, these interviews delved into why they would or could not develop the TrashWheel, or other like technology, within the system. Additionally, individual actors will be interviewed in this round to gain their perspective on why WPB and CM were able to fully develop the TrashWheel together and why other actors were unwilling or unable to.

Semi-structure interviews will be used and the interview topics will be closely followed as it is designed to answer the research question. However, some deviation from the interview guide will be needed to verify and expand upon topics (RWJF, 2008). A description of the interview will be provided to the interviewees prior to the first interview so interviewees can prepare any needed information they might not know offhand for the interview.

This research carried out 7 interviews total: 2 interviews from 1 WPB interviewee, 2 interviews from 1 CM interviewee, and 3 interviews with 2 different interviewees from actors within the direct network. Please note that, in order to maximize participation and the number of interviewees, interviews were changed upon the requests of the NPOs and stakeholders, to meet their demands and restrictions. Additionally, 1 questionnaire was also given. One interview was adapted into a questionnaire and sent through WPB to a stakeholder that was only willing to participate in a questionnaire through WPB.

3.6 Data Analysis

For the data analysis of this research: Open coding and axial coding will be utilized to process the data collected from interviews. From the interviews, open coding will be utilized to identify and collect observations by fracturing the interview data into parts for examination. Each part is then analyzed to identify concepts and their respective properties within the dimension of IDNPO involvement in TIS systems (Scott & Medaugh, 2017). Following open coding, axial coding will then be used to relate the data together in order to reveal codes and categories. These categories will then be compared to reveal emergent themes within the phenomena to then make any observed theoretical claims (Allen, 2017). In the final step of the coding process, axial coding will again be used to link these activities to their impacted TIS function.

Additionally, a case-specific timeline of WPB's activities will be constructed to provide additional depth in understanding how WPB influenced the TrashWheel within the EWCUT system. It will also help to highlight findings from the interviews and their influence in the development of the TrashWheel over time. This timeline will be constructed from the data collected from the documentation review and interviews.

3.7 Ensuring Data Validity

In order to validate the collected data, data triangulation will be utilized. Data collected from the documentation review and the interviews that overlap will be triangulated against each other to check for consistency.

Though this research strives to remain impartial, there are a few unavoidable biases. There is only one interviewer and therefore the possibility of a personal bias. In order to address this, this research intends to provide as much transparency as possible by taking notes during the interview and, if permitted, recording the interviews and transcribing the interviews. Another bias can be presented by the actors themselves, as they can promote a self-serving bias. For this reason, this research intends to create an interview scheme and interview questions that are mindful of this and nonleading, as well as triangulate as much data as possible from the interviews to the documentation review.

4. Results

This section covers the results from the coding, which are laid out under determined, categorized themes to provide an understanding of how WPB was able to contribute to the TIS functions. These themes are then followed by a constructed timeline of the events around the TrashWheel and a final interpretation to tie the results together.

4.1 Interview Results

This portion of the research was exploratory and utilized open, axial coding techniques to unravel several overarching themes and their respective categories. In this we see how and in what ways WPB was able to contribute to many of the systems functions as an NPO, either individually or in collaboration with Clearwater Mills (CM).

4.1.1. Entrepreneurial Activities, Function 1 (F1)

For F1, there were a couple sets of observations on how WPB was able to contribute to this process. The first being the advantages that WPB has as an NPO. This consisted of WPB's characteristics; which allowed them to take risks, be flexible, incorporate creativity and humor and utilize their passion to drive this process:

"I think we were really open to the idea of bringing humor into it and getting creative. So one of the first things we did was put out a RFP to local media and creative agencies, and have them pitch ideas... I'm not sure other organizations would have been as risky or willing to do something quite like that."

Being able to take risks allowed them to experiment with marketing techniques and find how creativity and humor were assets to them in this respect. Additionally, they had the advantage of being flexible to take on different risks.

Additionally, the limitations of other types of organizations provides juxtaposition to further emphasize the need for NPO involvement that WPB filled. This includes differing missions from both for-profit and governmental organizations that kept them from taking on entrepreneurial activities in this TIS in the first place:

"... our primary mission is making sure that cargo can come in and out of our waterways. This is just- having environmental responsibilities as part of what we do. But our prime directive is to make sure that cargo can come in."

For-profits were also found to have more interest in contributing funds than taking on liabilities in public areas; while government entities were either too slow to get involved and/or had to face too many restrictions and get approvals from other organizations which kept them from being able to take risks and have flexibility like WPB did:

"I think it was instrumental in them being able to do it in that time frame that they did it. Because I think that non-profits a tendency to think outside the box. They're not

restricted by, you know, a whole bunch of guidelines and stuff... 'This is what we want to do, bring me your best idea. Let's see how we can raise the funds to get it done.' So they don't have all these other restrictions and stuff like a government agency does. I'm not saying that we never could have done it on our own. But probably not."

Furthermore, other organizations that might have been interested in developing the TrashWheel were perceived to lack the capacity to do so. Even in the case of CM, the inventor of the TrashWheel initially lacked the capacity to fully develop the TrashWheel as an innovation individually:

"I'm trying to think if there is any other, any other group that would have stepped in and done what we did... Maybe the city of Baltimore could have been the owner and operator of it. But they were not in a position to do so. They do contribute funding towards it every year. So no, you know I really can't think of another organization that would've."

Which leads into the next theme, collaboration, and its effect on F1. As mentioned, CM lacked the capacity to fully develop the TrashWheel and, by itself, WPB also lacked this capacity. However, by collaborating and pooling their abilities and resources, both WPB and CM were able to successfully push through this process. Firstly, both organizations had an incentive to collaborate because they both benefitted from this collaboration. Their missions aligned very well so that they could pursue the same goal, in this case the development of the TrashWheel.

"When I'd tell people what I was doing, I was going to clean up Baltimore Harbor. The response I got was 'Oh that will never happen.' You know, the people were sort of resigned that the harbor was filthy, dirty place. And I think Waterfront Partnership shared that same challenge, they wanted to go out and make it swimmable and fishable and they heard the same thing, 'That's never ever gonna happen.'"

They were also a good fit for one another and knew that there would be a mutual gain to further each other's agendas.

"Yes, so that was a huge opportunity for both of us and I'd say we have benefited from the success of Mr trash wheel and as obviously they have as well."

Without these benefits, WPB and CM could not or would not have come together to fully develop the TrashWheel and contribute to F1.

Their collaboration is also a result of their co-dependence on one another. In order to focus on the tasks that each organization had the ability and resources for, the innovation process and entrepreneurial activities were divided up between the two. This means that each organization is responsible for a different set of activities around the TrashWheel. With CM being responsible for the invention and engineering around maintaining the technology and WPB contributing to the rest.

"They added the googly eyes to it and they gave it a Twitter account and a Facebook page, and then an Instagram account... So they gave it a social media presence and a voice. We make it eat and they make it talk and see."

Specifically, WPB's NPO contribution within the collaboration includes; the completion of the outer design, by making it appealing to the public, marketing and assisting in scaling up the product.

"And I think- yeah that donation was huge. I think having real googly eyes on the trash wheels blew them up even more. People got even more excited about them. And just felt this- people were like friends with Mr trash wheel. They'd see him and take selfies and post on social media like, just hanging out with my best friend, or people would be like- people would literally travel to Baltimore to see Mr trash wheel and take pictures with him."

All of which allow WPB and CM to come together and take on an entrepreneurial role, seize market opportunity and turn what they had together into concrete action. Though it is important to note that this was not WPB's intended role, which ties back into the WPB's flexibility and the ability to take risks. This characteristic allowed them to be a better fit in collaborating with CM to make the TrashWheel happen.

"I think, waterfront partnership and Clearwater mills were really- has turned out to be a really great partnership. In that, we're very small and nimble organization and we were able to pivot and really focus on marketing for the trash wheels... was not originally the purpose of healthy harbor, it turned out to be a really great fit."

The last theme with elements that fall under F1 contributions has to do with opportunity. WPB and CM were able to seize an opportune moment by recognizing the potential in a collaborative effort with one another to take on entrepreneurial activities.

"It was just like the stars aligned. It was a perfect timing type of thing and it was, ... just that whole being in the right place at the right time, talking to the right people and you know and then making those connections. I mean, I think the biggest leap was Waterfront Partnership wanted to take a chance, you know, on this new technology and stuff. But yeah, I just think it was- I don't think there was anything else other than a perfect alignment of the stars."

Additionally, together they were able to recognize that the trash problem was a common problem that was being experienced by many and capitalize on that as a market opportunity.

"So we discovered the opportunity that was A) not just a problem of Baltimore and B) something that people were extremely interested in and willing to get behind so I think that that opportunity quickly presented itself."

4.1.2. Knowledge Development and Diffusion, Function 2 & 3 (F2, F3)

For F2, there were no notable observations that could be linked to this function to show how WPB might have contributed to this process differently as an IDNPO. However, when taking on knowledge diffusion for F3, there was a noteworthy challenge that WPB and CM had to overcome. That being the lack of public awareness, not only for the TrashWheel technology itself, but also for the problem that the TrashWheel was built to help solve; the trash problem.

"Well one of the big challenges is, first off, when I first started this project back in 2008. One thing was there wasn't a lot of attention being given, now you can hardly go a week or more without seeing some article somewhere on ocean plastics or plastics pollution, back then it wasn't quite that way."

Though with time and through educational programs, like those run by the WPB and other organizations, this lack of awareness was eventually addressed.

4.1.3. Guidance of the Search, Function 4 (F4)

When contributing to F4, one of the main contributors to their NPO advantage was their supporting network. Because the WPB is a business improvement district, whose mission is to keep Baltimore Harbor clean and safe, it was easier to express the vision of the TrashWheel and align expectations for EWCUTs in this network. There was a common interest in seeing Baltimore Harbor cleaned up and restored and therefore, in the eyes of stakeholders, the aligned expectation was that this EWCUT would contribute to the Harbor's viability by removing a significant and observable amount of trash to solve the trash problem in the area.

"Well the advantage was everyone had a vested interest in the harbour. See the harbour... and all the businesses along the harbour, if the harbour wasn't viable, it'd be out of business."

4.1.4. Market Formation and Resource Mobilization, Function 5 & 6 (F5, F6)

For F5, there were no notable observations that could be linked to this function to show how WPB might have contributed to this process differently as an IDNPO. However, for F6 there are many notable observations. As a business improvement district, WPB also had stable resources in the form of a supplemental tax that businesses along Baltimore Harbour in order to maintain the harbor's viability and in turn, the value of those businesses. This provided stable financial resources and human resources in the form of full-time staff.

"See, Waterfront Partnership was also a 501... non-profit. What they call a benefits district. It's funded by taxes from all the commercial properties along the harbour. And the biggest objective or mission of the harbour was safety, was trash... and crime. So they had safety people and they always address the trash in the harbour."

Furthermore, WPB had a lot of support from a robust network, especially in terms of financial support. As previously mentioned, because their job was to maintain the harbor's viability to

maintain the area's value, businesses along Baltimore Harbor were very invested in WPB's mission and in supporting their cause financially.

"Well one advantage is, all their board members were executives of all the major businesses along the harbour. That's where the money is... Just follow the money. And I'm not saying it derogatorily."

In terms of an advantage, there are inherent benefits of being an NPO in terms of what can be done legally, in terms of financials. Unlike other types of organizations, NPOs have the option to fund projects via fundraising, grant and donations and utilize volunteers for manpower.

"Also, NPOs have a different sort of relationship, work easier with others and are able to do things that for-profit companies can't, like fundraising."

This provides a strong contrast to the limitations of other types of organizations. Especially to governmental bodies, who in this case might not have even had the research and development budget to take on something like the TrashWheel.

Lastly, a significant challenge that WPB faced when mobilizing resources for the EWCUT system was the added responsibility of owning the trash once it was collected and the associated cost of properly disposing of it. On top of the usual resource mobilization activities surrounding an innovation, WPB had to mobilize additional resources to offset this continual cost.

"It's kinda sexy to be able to say we're building a trash wheel. It's not nearly as sexy to say we need, you know, we're getting rid of all this trash, which costs money to get rid of the trash that we collect so it's harder to fund getting rid of a dumpster than it is to, you know the fanfare of putting another one in."

These challenges are unique because they are not the usual challenges that entrepreneurs have to face in other sectors and they could act as a deterrent to other actors who would otherwise be interested in innovating within this system. WPB managed to mobilize these additional resources by utilizing several strategies, including: fundraising, building a business model that gains returns from selling TrashWheel merchandise, forming a volunteer group of dedicated members and garnering monetary support from governmental bodies that have to meet mitigation requirements.

4.1.5. Creation of Legitimacy, Function 7 (F7)

When contributing to the creation of legitimacy, WPB showcases many interesting observations on how NPOs can contribute differently. Firstly, as an NPO, one of the inherent benefits is the social aspect of trust. NPOs are seen as unbiased advocates with no ulterior motives, trying to make changes society will benefit from. Because of this trust, NPOs have a different sort of relationship with other actors and can work easier with them.

"Being a non-profit gives the advantage of advocacy and unquestioned motivation and trust. If a private company says they are doing something for the environment in their commercial, are they really?"

Additionally, WPB was able to build and maintain an extremely supportive network. In regards to the general public, their mission was resonating and appealing to more and more people and gathering support from those who believed in their advocacy message.

"Yeah I think we were really lucky in that, what we were doing was just resonating with people and we had- every year we'd pick up more and more followers, more and more passionate devotees to the trash wheel family."

They even managed to strengthen these bonds with the public by forming their 'Secret, Not-so-secret Society', a dedicated group of volunteers that supports the WPB and their mission. Furthermore, since the WPB was already invested in the cleanliness of Baltimore Harbor and a business improvement district, by the time they got involved in the development of the TrashWheel, they started with a very robust network. This included a diverse array of stakeholders who had a vested interest in what they were doing and the TrashWheel, as well as an individual network connector.

"Yeah, he was contracted... and I think he was also, I'm not sure if he was on the board at Waterfront Partnership, but he's on the board of a lot of those environmental advocacy groups and stuff like that or volunteers with them so yeah. It was one of those things where they had a need and- he was always trying to help us."

This individual had a strong dedication to cleanup efforts around the harbor and was able to take on an intermediary role and assist WPB in network building by matchmaking the Maryland Port Administration (MPA) with WPB, which eventually led to the MPA providing a substantial amount of funding for two TrashWheel projects. It also led to MPA owning a TrashWheel, that was built on their property, and have an agreement with WPB to make their TrashWheel part of the 'TrashWheel family' on social media. In addition to being a robust network, it was the 'right' network. What is meant by this is, the network had a lot of influential actors and those that were able to help propel the development of the TrashWheel.

"Well most of the board members of Waterfront Partnership, they were all executives of all the business all along the harbour. So they had invested... Yes, they had a lot of stake. And they were all professionals. And their president Laury Schwart, she has done a lot."

Tying back to Section 4.1.1, one of the things that WPB brought into their collaboration with CM was this business network. In terms of why an NPO was needed in this case, one of the limitations of CM (which we observe as an individual, since it consisted of one-person at the time) was its limited network knowledge. Since the individual only had experience with non-profit and governmental sectors, there was a limited working knowledge that kept CM from branching out to the for-profit sector that WPB was able to make up for.

This also applies to WPB's ability to continuously grow the network by appealing to the general public. In their collaboration with CM, one of WPB's main duties that it contributes to the TrashWheel is managing its social media platforms.

"So now we have Mr Trash Wheel has Facebook Instagram and Twitter, he has been number one on reddit I think three times."

This allows WPB to build more legitimacy around the TrashWheel innovation itself, as well as support their advocacy of building more awareness around the trash problem.

Though it is important to note, that while this is now strategically done, WPB originally happened upon the opportunity that social media platforms presented by accident.

"Adam went out to the trash wheel, took a video using his cell phone of the trash operating, like picking up a tire. Just kind of like physically standing on it, showing a world like this is how the device works and then that picked up a ton of steam. Hit a million views over one weekend, so it was our first taste of viral fame."

This led to WPB recognizing the widespread interest in the TrashWheel and utilizing viral fame as an advantage to shine a spotlight on it.

Luckily for WPB, the opportunity of social media helps with tackling the biggest challenge that the TrashWheel faces: Changing the status quo. In order to change the status quo, the mindset of the general public has to be changed. As one interviewee put it,

"And I think in a large extent we are still doing that... what we're competing against is the status quo which is, I think, let it go down the river and become somebody else's problem... - out into the harbor, or out into the bay, or out into the ocean, or onto a beach and let it become somebody else's problem. That's actually a fairly tough thing to compete against because it's free. And it happens naturally. And convincing somebody whether it be the government or nonprofit or a business entity that you know it's in their best interest and worth investing in doing that activity has been the challenge."

This was a particularly difficult issue when the TrashWheel first came out in 2008, before the global trash problem began to become more universally known and supported. Even though the idea to tackle the trash problem has gained more momentum, it is still hard to convince the general public and organizations that money has to be put into something like this, which is very expensive and labor intensive, that was not previously seen as an issue or as the responsibility of others.

The last, but most striking observation that was made about WPB's contribution to F7 is the simultaneous long-term destabilization. Many counter productive activities were noticed during this case study. The first being that the Trash Wheel is being used as an environmental symbol to help create awareness and behavioral change.

"And all of these technologies are sort of working together to raise the awareness of the problem and inspire people to be part of the solution I think."

Though this helps to support the TrashWheel and other technologies of the ilk in the short term, by spreading awareness of this type of technology and bringing in support from individuals and organizations alike who want to help support the clean-up of the environment, in the long-term it is detrimental to the existence of the EWCUT sector. The reason being that, the more that people and organizations become involved in their network and being part of the solution, the less trash there will be to cleanup in the long-run. Furthermore, if the trash problem is ever completely solved, there will be no trash for these technologies to clean up, making them obsolete. WPB and CM are seemingly well aware of this.

"I think that we really need to look at our use of single use plastics, we really need to look at our policies that allow us to continue to produce you know, containers that we use for ten seconds and discard. We have no good for means of reusing or recycling them. As more of the solution, you know the technologies can treat the symptoms of the disease but they're not really a cure for the whole disease."

They see these technologies as only temporary or partial solutions and WPB actively contributes to activities, like providing educational programs, that will ultimately lead to delegitimization of the EWCUT system in the long term. Those within the network, that are mainly interested in the trash problem, will shift from this system to another system with a more permanent solution.

The strange thing about the EWCUT sector is that it is very tied to the trash problem. Without the trash problem, the TrashWheel would not exist. Yet, actually solving the overall trash problem makes the need for TrashWheels and like-technology obsolete or, at the very least, a limited market in the long-term. However, instead of getting involved in activities that would counteract resistance to change to sustain this TIS (i.e. lobbying for the use of more disposable plastics to create more trash to keep the TrashWheel in business), WPB and CM embrace the idea of finding a real solution to the trash problem. Even if it ultimately leads to the demise of the TrashWheel and other like-innovations, WPB actively partakes in activities that give solving the trash problem precedence over preserving the EWCUT system.

4.1.6. Overall system, F1-F7

An important observation that was mentioned by two interviewees, that pertains to the entire system, highlights the importance of passion in driving processes within this system. Though the idea of NPOs being driven by passion is by no means a new one, the idea that passion was able to drive the WPB the way that profit drives for-profit entrepreneurs within a TIS is something that should be noted, as it is the motivation behind WPB's contribution to shaping the system and how they were able to take on such an immense undertaking.

"You know it's because it's- once you pick up the trash you own it. So you got to do something with it. And there's... expense involved in doing that and it's- you've got to be kind of passionate and strongly committed to it in order to take that..."

4.2 TrashWheel Timeline

Additionally, a timeline of WPB's and CM's activities surrounding the TrashWheel was constructed utilizing data from the documentation review and interviews, as shown below in Figure 4.2.

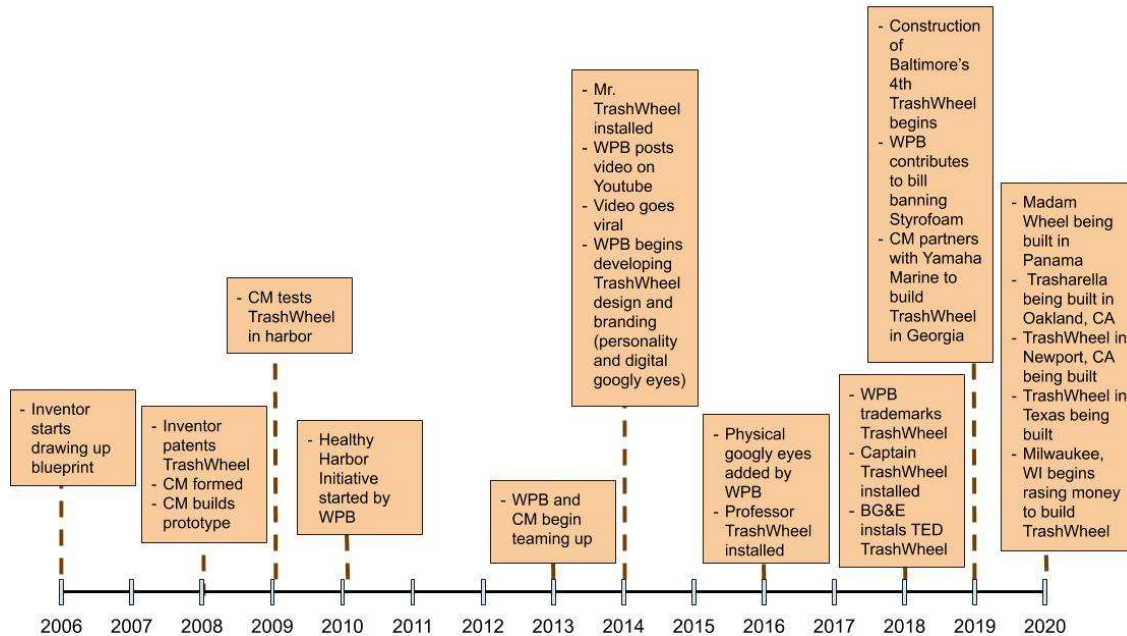


Figure 4.2 Timeline of the WPB's and CM's main activities around the TrashWheel (Mulvihill, 2018; Burris, 2015; Mr. Trash Wheel, N/A; Waterfront Partnership of Baltimore, 2018; Yeager, 2018; Milligan, 2019; Businesswire, 2019; O'Dowd, 2019; Davis, 2020; Matenaer, 2020; Meyer & Gokkon, 2020; Waste360, 2020)

As can be seen from the timeline, from 2006 to 2013, CM is the only one involved in the development of the TrashWheel during this time. Though they do receive some help from the Abell Foundation in order to obtain funds and permits to install and test run a prototype of the TrashWheel for a year, the system activity around the TrashWheel is quite limited and CM only contributes to F1 and F2 during this time. This is where we see the need for an NPO as we observe the limitation of the individual developing the TrashWheel. As mentioned in Sections 4.1.1 and 4.1.5, the individual did not have the capacity to fully develop the innovation and limited network knowledge to bring in other actors for support, which affected CM's contributions to F1 and F7, respectively, during this time. In 2010, WPB begins its Healthy Harbor Initiative, with the goal to clean-up Baltimore Harbor. Is it at this point that we see WPB develop a mission that aligns with CM's mission, which will eventually allow them both to benefit in a full collaboration and contribute to F1 together (covered in Section 4.1.1).

After CM's and WPB's partnership in 2013, we see a jump in activities contributing to the TIS. In 2014, we see Mr. TrashWheel get installed. This can be attributed to WPB's NPO advantage of having a robust network to draw support. This is when the individual network connector acted as a system intermediary to match make WPB with MPA and helped WPB to avoid system failure in F7 by adding important actors to the network (covered in Section 4.1.5).

With MPA added to the network, WPB was able to mobilize the financial support needed from their robust network to build the first Trash Wheel and contribute to F6 (covered in Section 4.1.4). In this time WPB also managed to line up actors with a common interest and bring in a diverse array of stakeholders who all had a vested interest in cleaning up Baltimore Harbor that allowed them to contribute to F4 and F7 (covered in Sections 4.1.3. and 4.1.5, respectively). WPB then posts the video on Youtube, where it goes viral. Not only does this grow the network and add to F7 by spreading awareness of the TrashWheel (Section 4.1.3), but it also shows that there is widespread interest in solving this common problem, which reveals an opportunity and allows WPB and CM to pursue this and contribute to F1 (relates back to 4.1.1). This also the year that WPB becomes more integrated with CM and fully collaborates as co-developer of the TrashWheel. WPB begins developing the TrashWheel branding and external design. Their NPO contribution to the design and marketing allows them to contribute to F1, while their social media management allows them to continuously contribute to F7 (Sections 4.1.1 and 4.1.5).

After 2014, a scaling up and diffusion of the TrashWheel technology starts to be observed. After WPB's contributions in 2014, in 2015 we begin to see a result of the TrashWheel's F4 contribution, as the first case of TrashWheel imitation technology by TOC is observed (Figure 3.3). In 2016, a second TrashWheel is built and WPB finishes the full development of the TrashWheel by adding physical googly eyes to the design, contributing to F1 (Section 4.1.1). Then, in 2018, the first two cases of TrashWheels being owned by organizations other than the WPB are built. The two organizations that commissioned these TrashWheels were MPA and Baltimore Gas and Electric (BG&E) and show that the technology is beginning to scale-up as there is an established demand. Additionally, WPB contributes to F2 by trademarking the TrashWheel. In 2019, we see another TrashWheel being built. More interestingly, we see evidence of WPB contributing to the long-term destabilization of this TIS by contributing to F7 (Section 4.1.5). In order to address the trash problem, the WPB contributed to a bill that bans Styrofoam in Maryland, the first ban of its kind in the country. We also see CM contribute to growing the network by partnering with another organization to build another TrashWheel and contribute to F7. Lastly, in 2020, we see many plans and ongoing developments for TrashWheels begin to sprout up. This shows a further scaling-up and diffusion of this technology, as these are the first TrashWheels to be built outside of Maryland, and their locations are spread throughout the US. Furthermore, one case will be the first TrashWheel located outside of the US. Additionally, many of these TrashWheel follow in the footsteps of WPB's design, with personalities and humorous names to help make them appealing to the public and garner support.

4.3 Results Summary

As can be seen from Sections 4.1 and 4.2, WPB has made quite an impact on the development of the TrashWheel and its respective EWCUT system. The gathered results from this research allow us to construct a story behind WPB's involvement and to help this research capture the difference that WPB made, why they were crucial and why other actors could not fully develop the TrashWheel or similar technology within this TIS.

| Theme | Category | Sub-Category | Code | Function-linked Code |
|---|----------------------------------|----------------|--|---|
| NPO Advantage | Stable Resources | Financial | business improvement district NPO | Resource Moilization (F6) |
| NPO Advantage | Stable Resources | Human | Full-time Staff | Resource Moilization (F6) |
| NPO Advantage | Characteristics | | Risk Taking | Entrepreneurial Activities (F1) |
| NPO Advantage | Characteristics | | Flexibility | Entrepreneurial Activities (F1) |
| NPO Advantage | Characteristics | | Creativity and Humour | Entrepreneurial Activities (F1) |
| NPO Advantage | Characteristics | | Passion | All Functions (F1-F7) |
| NPO Advantage | Support | Public | Appeals to people | Creation of Legitimacy (F7) |
| NPO Advantage | Support | Public | Dedicated members | Creation of Legitimacy (F7) |
| NPO Advantage | Support | Robust Network | Diverse Array of Stakeholders | Creation of Legitimacy (F7) |
| NPO Advantage | Support | Robust Network | Individual network connector | Intermediary F7 (Network building by match making) |
| NPO Advantage | Support | Robust Network | Right Network | Creation of Legitimacy (F7) |
| NPO Advantage | Support | Robust Network | Common interest | Guidance of the Search (F4) |
| NPO Advantage | Support | Robust Network | Financial Support | Resource Moilization (F6) |
| NPO Advantage | Inherent benefits | Social | Trust | Creation of Legitimacy (F7) |
| NPO Advantage | Inherent benefits | Social | Relationships | Creation of Legitimacy (F7) |
| NPO Advantage | Inherent benefits | Legalities | Funding and financials | Resource Moilization (F6) |
| Opportunities | Opportune Moments | | Right people, right place, right time | Entrepreneurial Activities (F1) |
| Opportunities | Widespread Interest | | Common Problem | Entrepreneurial Activities (F1) |
| Simultaneous Long-term Destabilization | Counter Productive Activities | | Temporary/ Partial Solution | Creation of Legitimacy (F7) |
| Simultaneous Long-term Destabilization | Counter Productive Activities | | Awareness and Behavioral Change | Creation of Legitimacy (F7) |
| Challenges | Status Quo | | Changing People's Minds | Creation of Legitimacy (F7) |
| Challenges | Status Quo | | Lack of Awareness | Knowledge diffusion (F3) |
| Challenges | Added Responsibility | | Trash Ownership and Costs | Resource Moilization (F6) |
| Collaboration | NPO Contribution | | Design | Entrepreneurial Activities (F1) |
| Collaboration | NPO Contribution | | Marketing | Entrepreneurial Activities (F1) |
| Collaboration | NPO Contribution | | Social Media Management | Creation of Legitimacy (F7) |
| Collaboration | Co-dependence | | Division of Tasks | Entrepreneurial Activities (F1) |
| Collaboration | Benefit | | Mission alignment | Entrepreneurial Activities (F1) |
| Collaboration | Benefit | | Good fit | Entrepreneurial Activities (F1) |
| Collaboration | Benefit | | Mutual Gain | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | Government | Slow involvement | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | Government | Differing Missions | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | Government | Restrictions and Approvals | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | Government | R&D Budget | Resource Moilization (F6) |
| Need for NPO | Limitations | Government | Capacity | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | Individual | Limited Network Knowledge | Creation of Legitimacy (F7) |
| Need for NPO | Limitations | Individual | Capacity | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | For-profit | Liability | Entrepreneurial Activities (F1) |
| Need for NPO | Limitations | For-profit | Differing Missions | Entrepreneurial Activities (F1) |

Table 4.3 A comprehensive summary of the TIS system mapping and function linkage, as explained in Sections 4.1.1- 4.1.6.

As mentioned in Section 1, NPOs fill the gap between the public and private sectors. This research shows that this gap includes the need for entrepreneurial actors that develop innovations within innovation systems. In this particular case, there was a promising technology, the TrashWheel, that was being developed by an individual (who later established the company CM). However, as seen in Section 4.2, CM was only able to bring the technology so far, at a slow pace and with fewer contributions to the TIS functions. As seen in Table 4.3 above, which summarizes the findings from Section 4.1, the need for an NPO stems from CM's limitations as an individual and contributes to the lag that we see prior to 2013 in Figure 4.2.

Additionally, the limitations of other types of actors (listed in Table 4.3) keeps them from being part of the TrashWheel timeline (in Figure 4.2), which creates a need for an NPO and allows WPB to fill that gap.

As mentioned in Section 4.1, it was not WPB's original intention to fill the role that they did. We see this in Figure 4.2, as there is a time gap between the year that WPB joins with CM (2013) and when they actually start contributing to the TrashWheel's development and F1 (2014). Originally, WPB's only intention was to support the TrashWheel by helping them to overcome challenges within the TIS around the trash problem (in Table 4.3) and to help mobilize resources by pulling support from their robust network and making use of their inherent benefits (in Table 4.3 under 'NPO Advantage'). However, the benefits of a collaboration (in Table 4.3), coupled with WPB's characteristics of flexibility, risk taking and passion (in Table 4.3 under 'NPO Advantage') allowed them to recognize an opportune moment (in Table 4.3 under 'Opportunities') and contribute fully to the TrashWheel development and develop a co-dependence with CM (in Table 4.3 under 'Collaboration').

After WPB's collaboration with CM to fully develop the TrashWheel in 2014, we begin to see a flurry of activity around the TrashWheel that is more diverse in its contributions to the TIS functions (in Figure 4.2). WPB's social media management (in Table 4.3 under 'Collaboration') leads to the discovery that there is widespread interest in this type of technology (in Table 4.3 under 'Opportunities'). By managing the TrashWheel's online social media accounts and using it to reach out to people in the public space, it allows WPB to garner more support from the public for the TrashWheel and helps gather a dedicated group of members committed to the cause (in Table 4.3 under 'NPO Advantage'). This also gives WPB the ability to utilize the TrashWheel's success to tackle the trash problem specifically. As can be seen in Figure 4.2, in 2019 a significant outcome of WPB's activities contributing to the long-term destabilization (in Table 4.3) of the EWCUT TIS is observed in the form of a state-wide ban on Styrofoam, as WPB gives priority to the overall trash problem.

In summation, the results from the coding and timeline highlight 4 significant findings:

- 1) The first emphasizes why other actors were unwilling or unable to develop the TrashWheel or a similar technology. Other actors lacked the capacity, had different missions that did not align with the EWCUT and/or other reasons listed in Table 4.3. These attributes resulted in the actors' limitations within this TIS and kept them from getting directly involved or having the ability to fully develop the TrashWheel individually. These limitations resulted in a need for an NPO.
- 2) The second emphasizes how NPOs were able to address these needs and what advantages they had to overcome the limitations faced by other actors. WPB was crucial to the TrashWheel because they brought in tools, characteristics, network support and other attributes (listed in Table 4.3) that were needed to contribute to the TIS. Therefore, WPB was crucial in the development of the TrashWheel because of its advantages as an NPO. Without it, the outcome of the TrashWheel would have been much different.
- 3) Though WPB did play a big part in the TrashWheels development, as can be seen in Figure 4.2, there would be no TrashWheel without CM, as they were the ones who got the TrashWheel technology started and owned the rights to it. Like other actors in the

system, the WPB had limitations, but it overcame these limitations by taking into account what it had and lining up with CM to make the TrashWheel happen. In this specific case, collaboration was key and WPB and CM's perfect alignment and symbiotic relationship was a big contributor to the TrashWheel development and to the EWCUT sector.

- 4) Lastly, the biggest difference that WPB made to the EWCU sector was by simultaneously contributing to the TrashWheel as well as utilizing the TrashWheel to benefit other approaches to address the overall problem. By helping CM to fully develop the TrashWheel, they were then able to use the platform of the TrashWheel as a steppingstone to get to solving the trash problem. Unlike other types of entrepreneurial actors who are working to build and preserve the TIS, WPB is building the TIS as part of a strategy to solve a root problem that takes away from the TIS. This really emphasizes how NPOs can contribute to a TIS in a different way and with a different end goal.

5. Discussion

In this section, the four main findings from this research will be discussed. It was found that NPOs are capable of driving innovation within TISs by (1) filling gaps left by public and private actors, (2) utilizing advantages available to non-profits, (3) exploiting synergies from NPO collaboration with for-profit actors and (4) solving the trash problem by simultaneously pushing the TrashWheel technology as well as investing in other approaches to reduce the need for this type of technology.

5.1 NPO Advantage

The first way that WPB was able to drive innovation within the EWCUT sector was by having several advantages as an NPO. Since NPOs serve the public, WPB's journey to creating legitimacy was made easier in comparison to for-profit actors. Inherently, NPOs are seen as more trustworthy and have an easier time building relationships with other actors. It was easier for WPB to gain support from the public, as well as from other organizations, and build their network because their cause served the good of the public, the interests of other organizations and was not in self-interest. This is further emphasized by NPOs being motivated by passion rather than by profit, which, in the eyes of others, makes them less susceptible to greed and other nefarious characteristics. On the downside, NPOs' service to public interests could make other actors doubtful of their managerial and innovation capabilities as an NPO, hence the popularity of privatization. Passion is not perceived to be 'as strong' or 'as professional' of a motivator as profit.

In terms of NPO financial benefits, as a non-profit business improvement district, WPB has a stable inflow of income from the benefits tax collected from businesses in the area and full-time staff to keep the Baltimore Harbor area clean and safe. This provides a consistent inflow of resources that can be mobilized and, in combination with grants, donations, and fundraising opportunities that are only available to NPOs, it gives NPOs a financial advantage in being able to pull additional financial support through options that are not available to other actors. For-profit entities have a limited set of financial options and must usually take out loans, get investors or develop a successful business model in order to have the financials to innovate. Meanwhile, NPOs have access to most of the same options, as well as the aforementioned 'NPO-only' options. The downside of this being that NPOs are not allowed to make a surplus of revenue, since legally all profits must be reinvested into achieving the mission. This means that there is less financial incentive for for-profit organizations to provide monetary funds to NPOs, as they are categorized as donations and not investments, and NPOs can be limited to what other organizations and the public are willing to 'give', especially if they do not develop a business model to sustain themselves.

Finally, WPB has many characteristics, including risk taking and flexibility, that allowed them to successfully take on entrepreneurial activities. Though these qualities do not really differentiate NPOs from for-profit organizations, as they can be utilized by both, these characteristics are a big distinguisher between NPOs and governmental organizations. Both NPOs and governmental organizations serve the public and are not intended to make profit, so

there are a lot of parallels between these two types of organizations. However, governmental entities are generally cumbersome, not as willing to take on risks and their decisions can be limited by regulations and approvals, unlike what we saw with WPB. Because governments are funded by the public in a non-voluntary way, they endure a higher degree of public scrutiny than NPOs - which manifests in the way that they operate. It explains why government organizations are more likely to try and stimulate activity around something new and publicly beneficial, by providing things like grants and funding, rather than get involved themselves. Furthermore, they serve the general public, whereas NPOs can serve either the general public or smaller portions of the public. For governmental organizations, this means that problems like the trash problem, which in the beginning stages of awareness was only known to a small portion of the public and was not known or of concern to the general public, are less likely to be of concern to governmental organizations. This dependency on the general public opinion means that governments can be slow at getting involved. On the flip side, because NPOs operate in the space between private and public organizations, if a government organization did decide that it was their responsibility and step in, NPOs face the risk of being forced out or taken over by the governmental entity (Zimmerman, 1999). In this regard, NPOs are not as well protected as for-profits are, nor are they as powerful as or have more priority over solutions like governmental entities do.

It is important to note that though not all NPOs may have all of these same advantages to work with, nor do we know what specific combinations or mechanisms provide the keys to success, we know how each advantage affects how an IDNPO can better contribute to these processes and drive innovation in comparison with other types of entrepreneurial actors.

5.2 Collaboration

The second way that WPB was able to drive innovation was by collaborating with CM. WPB and CM managed to build a symbiotic relationship, in terms of developing the TrashWheel innovation, and would not have been part of this system without one another. Both benefitted from the collaboration since their missions aligned, the organizations fit well together and both received gains. This allowed them help build off each other when taking part in entrepreneurial activities and to drive this process together in a single direction. They also established co-dependency by divvying up the activities around the TrashWheel so that each was responsible for a different group of tasks and they could take on the process of entrepreneurial activities easier by focusing only on the tasks they were responsible for. In terms of what WPB was able to contribute, to entrepreneurial activities they contributed to the activities around visual design and marketing. They also manage the social media accounts in an effort to market by creating more legitimacy around the TrashWheel. Though not every entrepreneurial actor needs a collaboration to be successful, in WPB's case, a collaboration was needed. How WPB managed to have a successful collaboration with CM to contribute to two processes within the system and drive it shows us that other IDNPOs that have limitations and cannot fulfill the entrepreneurial activity function by themselves might be able to drive a system by collaborating

with another actor. It also shows what might be needed between the IDNPO and the other actor for this to be a possibility.

Though it is widely known that collaborations can be useful when developing an innovation, what was unexpected in these findings were the nuances of an IDNPO and for-profit collaboration in comparison to other combinations of actor collaborations. As mentioned in Section 5.1, each actor has access to a different set of financial tools. NPOs have access to fundraising, donations, grants, etc., while for-profits have access to business loan programs, investors and surplus revenue. Together, each actor is able to benefit either directly or indirectly from these combined financial options and are better able to pool the finances needed to develop an expensive and resource intensive innovation. Another observation is that the non-profit and for-profit collaboration did not affect WPB's legitimacy or the public's trust in them. Instead of being seen as an NPO that sided with the for-profit industry and developing questionable intentions, they maintained their reputation as an NPO and their relationships with the public and other actors. Finally, but most interestingly, are the protections that the for-profit organization offers the NPO in a collaboration. As mentioned in Section 5.1, NPOs operate between governmental and for-profit organizations and a governmental entity can push an NPO out or take over if the problem the NPO is solving is perceived to be a concern of the general public and a responsibility of the government. However, government entities are less inclined to push for-profit actors out in the same way, as it could stifle the free market. Therefore, an NPO's collaboration with a for-profit actor better protects the space it is operating in and lets it operate under the umbrella of a privatized sector.

5.3 Limitations of Other Actors

The third way in which WPB was able to drive innovation within this sector was by filling the gap left by other actors in the system. This shows in what ways WPB was needed and what they were able to overcome as an NPO that other types of actors could not. Depending on the governmental entity, governmental organizations were unable to take on entrepreneurial activities for a range of reasons, from having restrictions and needing approvals to slow involvement. The lack of governmental R&D budget was also an issue in terms of mobilizing financial resources. Other types of organizations, like for-profits, were not interested in developing or taking on the liability of this type of technology. Furthermore, as mentioned in the previous paragraph, CM lacked the ability to develop the TrashWheel alone. At the time, CM consisted of only one individual and lacked the network knowledge to create legitimacy and the capacity to take on all of the entrepreneurial activities without a collaboration. Though no set of circumstances will ever be exact for each system, WPB shows in what ways IDNPOs could meet different needs within the system to drive it that other entrepreneurial actors either cannot or will not meet when mobilizing resources, creating legitimacy or taking on entrepreneurial activities. This can be done by either meeting that need themselves, or by strategically teaming up with other actors in a collaboration in the case that they also have limitations.

Moving into the opportunities and challenges that WPB encountered and overcame within the EWCUT system, there were a couple notable opportunities. Their involvement in entrepreneurial activities presented them with opportune moments and revealed that there was a widespread interest in this type of technology. Though the TrashWheel was originally installed to solve the trash problem of Baltimore Harbor, WPB quickly discovered that this interest extended far beyond the borders of Baltimore, as people everywhere were beginning to take notice of the trash problem. WPB also faced two significant challenges that are unique to the EWCUT sectors. The first is the added, continuous responsibility of dealing with the collected trash, since whoever collects it owns it. Proper disposal of heaps of trash is time consuming and expensive, yet WPB manages to consistently mobilize the additional resources. The second challenge they face is having to change the status quo, which they tackle in two ways. WPB creates legitimacy by trying to change people's minds and get them to understand that the trash problem is an actual problem and something everyone needs to take responsibility for, which incorporates them into the system's growing network. They then diffuse knowledge to raise awareness about the solutions to the trash problem. How WPB was able to drive innovation was by recognizing opportunity while being involved in entrepreneurial activities and being able to stay above the challenges that the EWCUT sector presented in resource mobilization, knowledge diffusion and creation of legitimacy. Not only does this indicate the types of opportunities challenges that IDNPOs and other types of actors can face in these types of sectors, but it also shows that IDNPOs are capable of seizing opportunity and overcoming these challenges to continue to drive the system.

5.4 Simultaneous Solution Building

The last way that WPB drives the EWCUT system is very peculiar. The findings of this research revealed that WPB not only contributes to the building up of the innovation system by creating legitimacy, but also to its long-term destabilization of this same process by taking part in counter-productive activities to undermine that legitimacy. The reason for this revolves around the trash problem that WPB wants to address. The TrashWheel was innovated to help address the trash problem, so while the TrashWheel is the most viable solution to the trash problem, it will continue to gain legitimacy. However, WPB also simultaneously partakes in activities, like running educational programs to educate the public on how to waste less and recycle, as another solution to undermine that legitimacy in the future. They also helped to lobby outlawing the use of non-biodegradable waste and both WPB and CM have even acknowledged that the TrashWheel and technologies like it are only a cure for the symptoms and not the real problem. In the end, both organizations believe that there are other, more permanent solutions for the trash problem. Therefore, it creates this idea that the TrashWheel and other like technologies are only a temporary or partial solution. Though this might not affect the EWCUT system anytime soon and currently benefits it, in the very long run when the amount of trash is minimized or eliminated, there will no longer be a need or as much as a need for the TrashWheel. This is something that is outside the explanation of TIS function theory. Yet, this research has observed an IDNPO taking on the role of an entrepreneurial actor and driving a system by contributing to its legitimization and delegitimization. Therefore, this

research shows that NPOs do not only develop technologies at the center of certain TISs, but they are also invested in other solutions that solve the same core problem at the meta-level. As a result, IDNPOs will not always need the technologies they develop, whereas, other types of actors are invested in the technology itself and are less likely to take on other approaches that would ultimately solve the root of the problem.

What is also interesting is that WPB is not only developing the TrashWheel as a short-term solution, but it is also utilizing it as a platform and learning tool to pursue other avenues. It uses the TrashWheel as an environmental symbol for water cleanup efforts, as an educational source by showing the public how much trash is being picked up by the TrashWheels and to bring more attention to the trash problem and recycling. A good example of this was when WPB used the data that was amassed from the TrashWheel's trash sorting to show the large amounts of Styrofoam that was collected. This information was then used to support another advocacy group's lobbying for the Styrofoam ban. Therefore, WPB shows that IDNPOs can build different solutions off one another in an effort to solve the meta-level problem.

6. Conclusion

Within this conclusion section, the research question will be formally answered and the theoretical implications, practical implications and limitations of this research will be covered.

6.1 Theoretical Contributions

The main goal of this research was to establish a basis for IDNPOs within Innovation Systems Theory. Though they have previously not been distinguished from other entrepreneurial actors under general systems theory and literature only distinguishes them as intermediaries (Berrone et al. 2013), this research shows that IDNPOs are distinguishable in how they contribute to driving the system and give a glimpse into their potential to strengthen the system by addressing the research question: *How was WPB able to drive innovation within the environmental water clean-up technological sector, and what can we learn about NPOs' innovation system strengthening potential in general?* This research found that WPB was able to drive innovation within the EWCUT sector by filling the entrepreneurial actor gap left by other actors, whose limitations kept them from being able to, or fully being able to, fill this role. WPB also had its own set of advantages as an NPO that are not available, or at least not as readily available, to other types actors, which helped them to fill this entrepreneurial role and contribute to developing the TrashWheel. Another reason that WPB was able to become an entrepreneurial actor was because of their collaboration with a for-profit actor, CM, which allowed WPB to overcome its own limitations and provides a safer space for WPB to operate in between the public and private sectors. Finally, WPB is able to drive the TIS by trying to help solve the trash problem, which simultaneously creates legitimacy for the TrashWheel in the short-term while delegitimizing this same technology in the long-term. Though not all NPOs are created equal, the ways in which WPB drove the EWCUT sector gives insight into some of the strengthening potential of NPOs within an innovation system. NPOs that become IDNPOs have the potential to strengthen a system in ways that can differ from other types of entrepreneurial actors, as they can fill limitation gaps, have organizational-specific advantages and give priority to solving the problem rather than staying attached to the technology.

This research also reinforces other strings of literature and helps to connect a few fragmented pieces around the topic of NPOs and innovation. On recent study takes on a similar approach to this paper, by expanding on the roles of NPOs beyond that of their known roles as intermediaries and users of innovation (Molloy et al., 2020). It has found that NPOs can also take on roles as innovation champions, which are important drivers of social innovation, within a multilevel framework. It emphasizes that NPOs differ from other types of innovation champions, as they can utilize bricolage activity as a permanent solution instead of a temporary one (Molloy et al., 2020). Though this paper builds from a different theory, together with this research, they both contribute to broadening our understanding of NPO potential and both distinguish NPOs from other types of organizations in these same roles. This helps to emphasize a growing interest in this area of NPOs.

Additionally, this research on IDNPOs relates to literature on governmental organizations. One paper found that governmental organizations that are sources of innovation also have innovations that run counter to existing structures and found that challenging the status quo is a major source of innovation for these organizations (Considine & Lewis, 2007; Kamarck, 2004). This strongly relates to WPB's involvement in the TrashWheel and how it is used to address the status quo around the trash problem. Therefore, this research adds to this pre-existing literature by showing a way in which other types of organizations challenge the status quo, that governmental bodies might be able to learn from. It also introduces the NPO actor as one with similar goals, which might make an NPO a good choice for a collaboration or network partner. Another paper found that government organizations can utilize the elements of trust, commitment and common goals to help create a common ground for citizens and other actors and to help deal with the challenge of sustainability (Ooms et al., 2020). This is very similar to how WPB utilized its advantage of trust as an NPO, passion and commitment to the trash problem and lined up the common goals of other actors who had a vested interest in Baltimore Harbor in order to take on the sustainability challenge of the trash problem. Therefore, this research helps to support that these tactics work not only help to deal with the general challenge of sustainability, but also in developing innovations that support this sustainability. Furthermore, NPOs can utilize these same tactics, just on a much smaller scale than a national government.

Lastly, this research contributes to recent theories around 'temporary' IS systems, like mission-orientated innovation systems (MIS) and problem-orientated innovation systems (PIS) (Hekkert et al., 2020; Ghazinoory et al., 2020). As mentioned in Section 5.4, one of the things this research unveiled was WPB's dedication to solving the trash problem, even at the expense of the TIS that they helped to drive and the expense of the technology that they helped to develop. Activities were observed for WPB that both contribute to the EWCU TIS and take away from it in the long-term, making this TIS a temporary solution for a bigger problem. The purpose of MISs and PISs are to provide a framework for innovation systems that are built around missions or problems, ones that societies are trying to accomplish or solve at the macro-level (Hekkert et al., 2020; Ghazinoory et al., 2020). Once the mission is accomplished or the problem is solved, there would be little to no need for these systems. Therefore, this research adds to this preexisting literature by adding perspectives to the different levels and providing practical examples as to how actors are behaving. Specifically, how actors, particularly IDNPOs, can contribute to multiple solutions while addressing the same core problem at a meta-level and the TIS function activities around legitimization and delegitimization that these actors contribute at the micro-level.

6.2 Practical Contributions

There are several practical contributions that this research makes. WPB's involvement as an IDNPO within the innovation system can help to guide other NPOs in deciding how they can best contribute to strengthening an innovation system, whether that be as an intermediary or as an entrepreneurial actor. In a case where: (1) governmental actors face limitations due to slow

involvement, differing missions, restrictions and need for approvals and a lack of R&D budget, (2) individual actors face limitations in network knowledge and innovative capacity and (3) for-profit actors face limitations as the TIS does not align with their mission and the technology is perceived as too much of a liability; NPOs will have a more conducive environment to becoming entrepreneurial actors. Limitations to all three other types of actors creates a possible need for an NPO, since other actors are not able or not yet able to fill these entrepreneurial actor roles. Though this research cannot distinguish if it is the limitations of all three types of actors that creates this need or some combination of one or two types of actors.

The WPB case also shows NPOs what advantages they might have at their disposal that would help them to become successful IDNPOs. The first main advantage is that NPOs can gain trust and make relationships with other actors easier, inherent benefits that make it easier for an IDNPO to gain momentum and garner support for their innovation. Additionally, if the NPO was already well-established before becoming an IDNPO and had already built a network, this network could most likely be used to support the innovation. Especially since actors within the existing network already have common interests that relate to the IDNPO's mission, hence their pre-existence within the IDNPO's network, this makes it much easier to align expectations of stakeholders and benefits the innovation. Furthermore, since NPOs are dedicated to meeting public needs, they will most likely come across individuals who are also dedicated to that same cause and who are willing to help the NPO address it. As an IDNPO, this means that they could come across individuals that are able to take on roles as network connectors, volunteers or dedicated members, all of which are beneficial to growing the IDNPO's network and providing the IDNPO with human resources.

This research also shows how and why WPB was able to successfully collaborate with CM. Mission alignment and being a good fit were critical in contributing to the benefits that drew these organizations together. It is something that IDNPOs need to take into account when choosing a collaboration partner. WPB and CM also developed a symbiotic relationship by dividing up the tasks that contribute to the innovation, with the IDNPO finishing the full development of the innovation by contributing to the design, marketing and social media management. For IDNPOs that are unable to fully develop an innovation by themselves, this case shows how a collaboration, that works by divvying up tasks, can be beneficial and what they might be able to contribute if they lack technical skills. For actors that are not IDNPOs and are interested in collaborating with one, this helps to provide a better understanding of what IDNPOs within the system are capable of contributing, so that these other actors can best determine how they want to work with them and what the benefits are of networking with one.

This research also gives more general insight into how IDNPOs can balance financial and operational objectives. NPOs are always searching for the holy grail of financial stability (Weerawardena & Sullivan-Mort, 2001). Though this research did not specifically look into this area, it shows how an NPO was able to financially support the full development of an innovation, other activities around that innovation (e.g. educational programs), ongoing operational and maintenance costs of the innovations developed and the added costs of owning and properly disposing of the trash; all of which are extremely costly endeavors. WPB took this on by diversifying the sources of their financial income stream. Not only did WPB pull

financial support from more traditional routes, like fundraisers and donations, but they also utilized more modern NPO techniques, like copying for-profit business models and selling TrashWheel merchandise. Additionally, as a benefits district type NPO, they collected a benefits tax that resulted in a steady income for cleaning up the harbor. They also teamed up with local businesses to produce TrashWheel products, where they benefit from a percentage of the proceeds. An example of this are their TrashWheel beers, that are produced and sold by their local Peabody Heights Brewery. Furthermore, WPB capitalized on an opportunity to help a government organization meet their mitigation requirements. By doing this, they managed to raise a significant amount of funding for their trashwheel projects from a government entity. Lastly, in the case that they dry-dock, they also have strong relationships with other NPOs with similar missions to help with the cost of managing the TrashWheels during financially lean times. Though not all NPOs will have access to all these financial options, this case does seem to emphasize that financial diversification is something that could work for IDNPOs.

6.3 Limitations

One of the limitations of this research is that it is a single case study that utilizes the innovation systems functions from innovation systems theory. Therefore, a full mapping was not completed since this research only used partial system mapping to evaluate WPB and there is a limit to the perspective that this research can give. Additionally, only interviews were used to assess TIS function contributions of WPB. Though interviewees from multiple actors within the network were interviewed, because they are from the same network they might be limited to their own actor bias as well as share a group bias, since they are from the same network and region. For the scope of this research, interviews and a partial mapping are sufficient enough to answer the research question, but for further research this limitation should be taken into consideration and a full mapping will need to be done to extend the scope to the entire TIS with other sources of data to avoid biases from interviewees. Furthermore, TISs also have their limitations. In this case, the TIS theory is limited in providing context-dependent information. Though generalizations can be made for IDNPOs from the WPB case, recreating the success of WPB within this innovation system by using TIS theory alone is not possible. Additionally, it does not provide the ability to measure the non-substitutability or precise importance of WPB's, and subsequently other NPO's, contributions to the system.

Another limitation of this research is that this case is built around an IDNPO working in collaboration with a for-profit actor. Though some of the findings of this collaboration can be generalized to include IDNPOs who are innovating individually and in collaboration with other types of actors. Some only apply to this specific type of NPO, for-profit collaboration. Therefore, these findings provide only a partial innovation development contribution for IDNPOs. This research is aware that IDNPOs that fully develop an innovation by themselves might contribute to the system in additional ways, ways that might make them more distinguishable in comparison to other type of entrepreneurial actors. Thus, though this was in-depth enough for this research to address the research question and begin an exploration within this field, this is something to take into consideration for further research. For future research

endeavors it would be worth looking into, to distinguish the difference between individual IDNPOs contributions and other types of IDNPO collaboration contributions. It would also help to assess the pros and cons of each arrangement. This would help to understand which findings are generalizations and which are specific to certain situations and provide a more complete innovation development contribution.

Lastly, one of the most promising directions for this research is in its contribution to newer theory on temporary innovation systems, like MIS and PIS frameworks (Hekkert et al., 2020; Ghazinoory et al., 2020). This research managed to uncover an actor that is actively partaking in activities that both contribute to the legitimization and delegitimization functions of a system in order to create a temporary TIS solution for the trash problem. For MIS and PIS theory streams, this means that the WPB case provides an example of how some actors are involved at the micro-level and how they might be managing their solutions and trying to solve the main problem at the meta-level. Additionally, WPB's goal to have no trash so that TrashWheels become obsolete in the future also shows that these actions are intentional and that actors within these systems can be aware that the solution will limit or put an end to their organization. Though this does contribute to giving additional perspectives to the different levels of temporary ISs and some details about actors within these types of systems, these findings are limited. Since it was part of an exploratory study, it lacks the structure to provide something more than an observation. More in-depth research is needed to uncover more activities of actors that contribute to these systems, the types and roles of actors, mechanisms, interactions, and more concrete contributions that can be used to help construct these theories in more detail.

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9. Appendix

9.1 Interview Consent Form

Interview Consent Form for Participants

Your signature on the consent form provided below indicates that you willingly agree to participate and as such:

- You will allow yourself to be interviewed by the researcher
- You will allow for the interview audio to be recorded
- You will allow for a transcript of the interview to be produced
- You will allow the information you contribute to be used for research and future publications
- You may withdraw consent at any time and discontinue participation without penalty
- You may redact any information given during the interview, any time before publication
- You may receive a signed copy of this consent form, a copy of your interview audio or interview transcript (at your request)

You should note that, as your participation in this interview is a voluntary act, any wish to stop the interview (regardless of reason or time), or refuse to answer a specific question or discontinue the participation in the research project, may be done so without having to give an explanation.

You may also choose to remain anonymous. Would you like to remain anonymous? YES / NO

Interview Consent Form

By signing this form, I agree to take part in the research project as explained above. I have read the explanatory statement above and declare that I fully understand that agreeing to take part in this project means that I also comply to the terms of this research.

Name of Participant:

Participant Signature:

Researcher Signature:

Date (DD-MM-YY): _____

9.2 Interview Guide

Dear (Interviewee),

As stated in my initial e-mail, I am a student following the MSc Innovation Sciences at Utrecht University and conducting interviews for my thesis. My thesis topic is covering non-profit organizations (NPOs) as sources/developers of innovation and their contributions to innovation systems; in an effort to better understand NPO significance in innovation. My preliminary research has indicated that the Waterfront Partnership of Baltimore and Clearwater Mills worked together to develop one. I am interested in Waterfront Partnership's involvement in the activities around the invention and development of the TrashWheel (e.g: involvement in demonstration projects, networking to support the TrashWheel, presenting it at conferences, any other related activities). I am trying to understand how these activities contribute to the technological innovation system and what major challenges and opportunities were encountered during its development.

I would like to record the interview, pending your approval. The interview itself will only be shared with my research advisor and will be deleted after this research has been completed. The data I collect will be available for publication, but you may request to remain anonymous. You are entitled to review your interview recording and the transcripts of your interview and redact any information you have given. You may also choose to end the interview at any time or skip any questions.

Thank you for your consideration and I am looking forward to the interview.

Best Regards,

Mai Bausch

Practicalities

Location: _____

Time: _____

Date: _____

9.3 Interview #1 for WPB and Collaborator

My name is Mai Bausch and I am a student following the MSc Innovation Sciences at Utrecht University. I am currently looking into NPO as sources and developers of environmental water clean-up technologies. Specifically, in relation into how non-profit organizations contribute to the innovation system.

Just to reiterate, you may also choose to stop the interview at any time, skip any questions or redact any information you have given at any time before the completion of this research. This is a voluntary interview, so what you choose to share is completely up to you.

Please ask me to clarify any questions that are unclear to you.

Before we begin, do you have any questions or have anything would you like to say?

I will now begin the recording. This recording will be deleted after the research is completed, sometime around July.

General

1. What is your name?
2. Which organization do you represent?
3. What type of organization is it (e.g. for-profit company, government, non-profit, startup, educational institution?)
4. Could you give a brief description about what your organization does and your role within it?

Involvement

5. Could you please tell me about your organization's involvement in the development of the TrashWheel?
6. What is your current involvement with the TrashWheel?

Challenges and Opportunities (innovation development)

7. How did the idea of the TrashWheel come about?
8. What was the inspiration behind its design?
9. Were there any large challenges faced during the development of the TrashWheel? What were they and how did you overcome them?
10. Were there any notable opportunities your company recognized and pursued? What were they?
11. Do you think anyone or any other organization would have pursued these opportunities if your organization did not?

Awareness and Exchange

12. What do you know about other environmental water clean-up technologies developed by non-profits, before and after the development of the TrashWheel?
13. Do you think these non-profit developers have benefitted from the development of the TrashWheel in any way?
14. Do you think your technology has benefitted from these non-profit technologies in any way?

System Mapping

15. What other activities, beyond the actual development itself, has your organization been involved in to support your innovation?

(If yes, ask them to elaborate. Skip questions that were previously answered.)

Taking on an entrepreneurial role?

Yes No

Turning knowledge developments, networks, and/or markets into concrete action?

Yes No

Seizing a market opportunity?

Yes No

Experimenting?

Yes No

Taking part in diversification activities?

Yes No

Entering into a new market or into an existing one?

Yes No

Producing new scientific knowledge?

Yes No

Learning from the new applications?

Yes No

Imitate something already in the market?

Yes No

Building off new knowledge during the R&D process?

Yes No

Contributing to or running R&D projects?

Yes No

Doing demonstration projects?

Yes No

Launching prototypes?

Yes No

Taking steps to protect its intellectual property? (e.g. patent filed)

Yes No

Publish any journal publications or reports?

Yes No

Exchanging information through your network (e.g. partners, collaborators, markets, governments, competitors)?

Yes No

Gave workshops or presented at conferences?

Yes No

Contributing to shaping the vision and expectations of technologies in the environmental water clean-up sector?

Yes No

Identify any problems associated with the current technology in the market?

Yes No

Identify any opportunities to guide this technology and others like it?

Yes No

Contribute to creating a space where your technology and others like it could emerge?

Yes No

Identify business opportunities?

Yes No

Help stimulate or create demand?

- Yes No
Mobilizing financial, human, or physical resources for the EWCU market?
- Yes No
Contribute to the interest of advocacy groups?
- Yes No
Involved in any lobbying?
- Yes No
Bring in new partners or collaborators?
- Yes No
Encouraged other business or organizations to get involved?
- Yes No
Utilize technology platforms?
- Yes No

Opportunities and Challenges (system)

16. Were any challenges faced when trying to complete these activities? For what activities where they present and what was the challenge? Was it/How was it overcome?
17. Were any opportunities faced when trying to complete these activities? For what activities where they present and what was the opportunity? Was it/How was it overcome?

Final Questions

18. Is there anything else you would like to add or comment on?
19. Can I contact you for any additional question for clarification if it is needed?

Thank you so much for your participation. I am now going to end the recording

9.4 Interview #1 for Stakeholders

My name is Mai Bausch and I am a student following the MSc Innovation Sciences at Utrecht University. I am currently looking into NPO as sources and developers of environmental water clean-up (EWCU) technologies. Specifically, in relation into how non-profit organizations contribute to the innovation system.

Just to reiterate, you may also choose to stop the interview at any time, skip any questions or redact any information you have given at any time before the completion of this research. This is a voluntary interview, so what you choose to share is completely up to you.

Please ask me to clarify any questions that are unclear to you.

Before we begin, do you have any questions or have anything would you like to say?

I will now begin the recording. This recording will be deleted after the research is completed, sometime around July.

1. What is your name and title?
2. Which organization do you represent?
3. What type of organization is it (e.g. for-profit company, government, NPO, startup, educational institution?)
4. Could you give a brief description about what your organization does and your role within it?

5. What is your entity's relationship with the Waterfront Partnership of Baltimore, WPB (e.g. stakeholder, partnership, collaborator)? Please describe in detail.
6. What has your entity contributed to the TrashWheel? WPB?
7. What does your entity have to gain, if anything, from this particular NPO's success?
8. What has the TrashWheel or WPB contributed to your entity?

9. Does your entity support any other organizations that are developing environmental water clean-up technologies? If so, what organization and what technology?

10. Please denote if you think that WPB contributes to or is part of any of the following activities for TrashWheel and other technologies like it (EWCU):
 - Taking on an entrepreneurial role? YES/NO
 - Turning knowledge developments, networks, and/or markets into concrete action? YES/NO
 - Seizing a market opportunity? YES/NO
 - Experimenting? YES/NO
 - Taking part in diversification activities? YES/NO
 - Entering into a new market or into an existing one? YES/NO
 - Producing new scientific knowledge? YES/NO
 - Learning from the new applications? YES/NO
 - Imitate something already in the market? YES/NO
 - Building off new knowledge during the R&D process? YES/NO
 - Contributing to or running R&D projects? YES/NO
 - Doing demonstration projects? YES/NO
 - Launching prototypes? YES/NO

- Taking steps to protect its intellectual property? (e.g. patent filed) YES/NO
 - Publish any journal publications or reports? YES/NO
 - Exchanging information through your network (e.g. partners, collaborators, markets, governments, competitors)? YES/NO
 - Gave workshops or presented at conferences? YES/NO
 - Contributing to shaping the vision and expectations of technologies in the environmental water clean-up sector? YES/NO
 - Identify any problems associated with the current technology in the market? YES/NO
 - Identify any opportunities to guide this technology and others like it? YES/NO
 - Contribute to creating a space where your technology and others like it could emerge? YES/NO
 - Identify business opportunities? YES/NO
 - Help stimulate or create demand? YES/NO
 - Mobilizing financial, human, or physical resources for the EWCU market? YES/NO
 - Contribute to the interest of advocacy groups? YES/NO
 - Involved in any lobbying? YES/NO
 - Bring in new partners or collaborators? YES/NO
 - Encouraged other business or organizations to get involved? YES/NO
 - Utilize technology platforms? YES/NO
11. Is there anything else you would like to add or comment on?
12. Can I contact you for any additional question for clarification if it is needed?

Thank you so much for your participation. I am now going to end the recording.

9.5 Interview #2 for WPB

Thank you for agreeing to a second interview. I have a few follow up questions to ask, building off of the previous interview.

Before we begin, do you have any questions for me?

I will now begin recording.

These questions are a lot different than the first interview. They are a bit vague and more complex, so please don't feel rushed to answer them and we can always skip questions and come back to them at the end.

1. If the WPB didn't step in to help develop the trash wheels, do you think another entity eventually would have? If so, who?
 2. What do you think made your organization capable of helping Clearwater Mills further develop the Trash Wheel (i.e. characteristics, capabilities, interests, etc.)? [For example, good reputation, willing to take risks, networking abilities, shared interests, etc.]
 3. In comparison to other types of organizations (e.g. governmental, for-profit) what advantage do you think being a non-profit brought to the table in helping develop the Trash Wheel?
 4. In comparison with other non-profits, what advantage do you think WPB brought to the table in helping develop the Trash Wheel?
 5. What is unique about what the WPB provided to the Trash Wheel? If Clearwater Mills had co-developed the Trash Wheel with another entity, what do you think would have been different about the trash wheel?
-

I will now wrap up the interview. Do you have any additional questions or requests?

Thank you again and I will now end the recording.

9.6 Interview #2 With Collaborator

Thank you for agreeing to a second interview. I have a few follow up questions to ask. As I mentioned, we are re-orientating the research around the TrashWheel for a single case study; though we will still be focusing on the non-profit organization aspect.

Before we begin, do you have any questions for me?

I will now begin recording.

1. In the previous interview you mentioned that when you had built a working model, many people from the mayor's office, department of public works and others came down to see it. They thought it was an interesting idea but because it had never been tried, they could not fund it as an experiment.
 - a. Do you know specifically why they were unable to fund it as an experiment?
 - b. Did you only approach governmental entities to help support the trash wheel?
If no: What other types of entities were there (e.g. for-profit, educational institutions) and what were the reasons behind their unwillingness/inability to support your endeavor?
2. Why do you think other entities were unwilling or unable to help further develop the trash wheel in the capacity that the non-profits did? [Or do you think they would have and it was just a matter of timing]?
3. Has a for-profit entity, or any entity, ever offered to buy your company out for the trashwheel or buy the trash wheel rights from you? Please elaborate.

You said also mentioned that the TrashWheel wouldn't be possible without the Abell Foundation or Waterfront Partnership:

4. What do you think made the Abell Foundation suited to help with the Trash Wheel prototype (i.e. characteristics, capabilities, interests, etc.)?
 - a. Why did they not continue with you into further development?
 5. What do you think made the Waterfront Partnership suited to taking on the initial Trash Wheels (i.e. characteristics, capabilities, interests, etc.)?
 - a. What unique thing did the Waterfront Partnership contribute to the trash wheel that you think no other organization would have ever recreated if they had picked up the Trash Wheel instead?
 6. Do you feel that being a non-profit contributed to the Abell Foundation's and WPB's suitability or ability to pick up the trash wheel? If yes, in what way?
-

I will now wrap up the interview. Do you have any additional questions or requests?

Thank you again and I will now end the recording.

9.7 Interview #2 for Stakeholders

Thank you for agreeing to a second interview. I have a few follow up questions to ask, building off of the previous interview.

Before we begin, do you have any questions for me?

I will now begin recording.

-
6. Why did the (name of interviewee's organization) choose to fund the initial Trash Wheels instead of owning the first few trash wheels? What were the contributing factors to this decision?
 7. Why did the (name of interviewee's organization) choose to recently own a Trash Wheel?
 8. If Waterfront Partnership never picked up and assisted in developing the Trash Wheel with Clearwater Mills, do you think the (name of interviewee's organization) would eventually have? Why or why not?
 - a. Do you know of any other organization (e.g. governmental, for-profit, non-profit, or educational institution) that might have? If none, why do you think no one else would have?
 9. What do you think made the Waterfront Partnership suited to taking on the first Trash Wheels (i.e. characteristics, capabilities, interests, etc.)?
 - b. What difference did the Waterfront Partnership make? Why were they crucial?
 - c. Do you feel that them being a non-profit contributed to their suitability to pick up the trash wheel? If yes, in what way? How does this suitability differ from other entities that are not non-profits (e.g. governmental, for-profit)?

I will now wrap up the interview. Do you have any additional questions or requests?

Thank you again and I will now end the recording.