Prospectus

Commercializing Better Biomaterials in Response to the China Sword Policy
(Technical Topic)

A MLP Analysis of the Failure of Consumer-Focused Policy in the Transition to a Circular Plastic Economy
(STS Topic)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

The circular economy has been theorized as the saving grace to prevent and restore human damages inflicted on the environment since the industrial revolution. Except in a few niche cases, attempts at achieving such a model have failed at various companies across various industries; however, emphasis on circularity continues to grow in response to the (ever-more) observable effects of air, ocean and ingestible pollution. New efforts are focused primarily on packaging, due to the frequent single-use nature, contamination collected during use and emphasis on consumer participation.

The paper (and more specifically cardboard) industry has seen the most successful implementation of circularity to date but is still riddled with flaws that reduce the success rate by nearly half. The technical component of my research will consist of analyzing this industry in an effort to create a plastic/paper packaging solution that can overcome forces that have hindered the circularization of the overlapping paper, plastic and packaging industries.

Our specific focus on the additives used to strengthen/coat paper serves as an anecdote for the true potential of biodegradable plastics and the need for an industry-led abandonment of traditional petroplastics and the complete circularization of the paper industry. Using MLP, the following STS analysis will address various failures of policy/diplomacy to align with consumer behavior innovative technologies that have inconsequently tightened the regime’s grasp in the fight against a sustainable transition to greener plastic alternatives.

Technical Topic

The 21st century will be defined by humans' ability to overcome linear product lifecycles. Single-use packaging and films, often comprised of paper and plastic, account for over 30% of American MSW (EPA, 2017). The industry's flaws were uncovered in 2018 when China, world's biggest importer of waste, passed the National Sword Policy. This law was passed with the intent of reducing annual waste imports to near zero by 2021 and has effectively reduced the imports of paper and plastic by over 60% and 95% respectively over the last 2 years (Staub, 2020). China's increasing demand for virgin fiber have resulted in global stockpiles of lower quality (recyclable) material, which are often coated in plastic to achieve the same performance as uncontaminated virgin fibers. Altogether, these factors have significantly increased the beginning and end of life impact of the paper packaging industry.

Circularization of the paper industry is within reach. Paper fiber is the most recycled consumer good in the planet, with over 92% of OCC being recovered annually (Staub, 2020b). We will investigate shortcomings of old corrugated cardboard (OCC) and coated paper recycling to develop a holistically (environmental, economic and socially accessible) sustainable solution in an effort to circularize the paper industry. Our technology will emphasize circularity, as well as the benefits derived by both consumers and industry, to create a solution that is reinforced by traditional practices and minimally disrupts existing infrastructure.

We will first perform stakeholder and online research to gain a stronger understanding of the forces driving the shift to sustainable products and impactful market applications. When a strong product/market fit has been identified, further

research will be performed into the specs/certifications required to meet industry standards.

Utilizing the UVA teaching lab spaces and data provided by Kombucha Biomaterials LLC and Transfoam LLC, we will test a variety of biomaterial blends consisting of bacterial cellulose (BC) and polyhydroxybutyrate (PHB). Background research suggests these materials offer unique abilities to increase the circularity of consumer paper products and have already begun steady integration into the market. Thermo and mechanical testing will be performed on successfully cured blends per the standards (pervasively ASTM, TAPPI and ISO) assessed above. If time and equipment/data permit, we will perform a broad impact assessment and assess future use cases to appeal more strongly to our industrial consumers and the downstream value chain. As a founder of Transfoam my primary roles are creating broad market discovery strategy to effectively align our interest with stakeholders and to provide data/expertise necessary to identify and achieve feasible specifications (for the plastic component of our product) determined by said market alignment.

Success will be measured at various points along the duration of the discovery, generation and analysis phases of our technical work. The discovery phase will conclude with the fall semester and will be measured by our ability to identify a reasonably sized set of standards demanded by our product application. Successful generation will consist of manufacturing a BC/PHB sheet and achieving, within a defined tolerance, the standards determined in the discovery phase. If we are unable to achieve either objective, we will rapidly iterate back through the discovery and generation cycle until successful. Success of the analysis phase is

currently less-well defined, and will be determined largely by the data collected in the previous phases. Keeping in mind our goal of creating the most holistically sustainable circular solution, this step will serve to double down on our success, more carefully measuring its impact along the product lifecycle and increasing consumer appeal.

STS Topic

Background

The idea of a circular economy is often accredited to Kenneth Boulding in 1966, when he theorized an "open" and "closed" economy (Allwood, 2014). Each was defined by the perceived nature of input resources and output sinks and correspond to the modern understanding of linear and circular economics (Boulding 1966). This idea has since been theorized by various sustainability advocate organizations, as well as environmental and economic theorists. Circularization of energy, particularly energy capture has been the main focus of the clear economic advantages and the global spotlight on climate change; however, these shifts are often incurred at the expense of the environment as a result of misalignment with consumer practice and government policy.

A Hessian interpretation of the traditional MLP technique allows for the consideration of forces that have not existed as staunchly in previous sustainable transitions (ST) that can be used to explain this misalignment, and, in particular, how it may be doing more harm to the environment than good with regard to the petroplastic regime. Hess suggests this regime, consisting of immensely powerful international companies and representative trade organizations, "mobilize against

ST policies that are perceived to threaten their short-term profitability and long-term existence." (Hess, 2014) This trend remains true, as environmental data and sector analyses suggest little synchronous progress has been made.

Scope

In a 2018 MLP analysis of the circular economy, the UN states, "Specifically, no concrete policy action has yet been taken to promote a rapid transition towards a circular economy paradigm." The document proceeds to encourage consumer participation in circular practices but strictly defines few measures to achieve such a goal (Pontoni, 2018). This leniency has allowed the petroplastics industry to support recycling infrastructure to further energy savings and appeal to consumers.

Recycling practices, particularly in the US where little has changed since its advent over 70 years ago, continue to inappropriately justify the use of unsustainable materials in single-use products and recover less than 9% of them used annually (Parker, 2018). The majority of these small plastic items can be labeled as packaging and are most often used in consumer foodservice products. These items comprise 40% of MSW by weight in the US and contribute heavily to pollution and recycling impurities due to contamination collected during use and end of life mismanagement, such as littering (EPA, 2018).

A variety of decentralized/localized and consumer-focused petroplastic-opposing and bioplastic-supporting ordinances and movements have been explored against the often overwhelming force of the incumbent regime, but have continuously overcome by the shear wealth and power that has allowed for unseen pushback against the landscape and niche due to a lack of alignment prominent

forces in among the establishment of new policy, rigid consumer practices and advancements in polymer technology.

The cases scrutinized highlight the historical failures of consumer-focused sustainable plastic policy, which have allowed the regime to push back on landscape policy through greenwashed technology and behind the scenes lobbying.

Oxo-"Bio"degradable Petroplastics

Oxo-degradation is a chemical innovation made in the 70s that utilizes the reactivity of oxygen species under UV to break material bonds. The technology was investigated by the petroplastic regime, but quickly died out due to an apparent lack of need for the property. As the word "biodegradable" grew more popular in the early 2000s; however, the petroplastic regime sought to take advantage of the loosely defined terminology. As such, oxo-degradable petroplastics, most often in expanded forms of polystyrene (PS) due to its low PS weight/volume ratio. To the public, these plastics degrade, assimilating seamlessly into the environment. While degradation in the environment is in fact expedited, it is the mere degradation into micro- and nano- plastics, which cause more environmental harm and are harder to collect than the larger, slowly degrading fragments of unmodified petroplastics. This, in addition to the small packaging waste used to seal/contain these larger goods, have contributed significantly to the exposure of the regimes blatant misapplication materials build to last indefinitely in single-use cases, and creatively furthering its agenda under the nose of the more closely aligned landscape and ST niche. In 2017, the worldwide landscape's (diplomatic and ST-promoting organizations) support of the New Plastics Economy initiative published by the Ellen

MacArthur Foundation quickly led to a global repudiation of oxo-degradable plastic packaging (EUBP, n.d.); however, many companies still have successful oxo-degradable product lines.

No policy has yet been imposed, but will soon be, and must be careful to name explicit *petroplastics* due to the inherent advantages oxo-degradation will one day present in compostable goods.

The European Union's Bio-Based Initiative

Nearly intertwined with the case above is the European Commission's Lead Market Initiative (LMI) in 2007. This government investment sought to stimulate consumer interest in greener, bio-based products, as well as the overall bioeconomy. In 2008, the Ad-hoc Advisory Group for Bio-based Products, representing European governments, industry and academic was established to innovate in unity towards goals laid out in the LMI (OECD, 2013). The terms highlighted in these goals, such as "bio-based" and "biodegradable," were ill defined, and the petroplastic regime once capitalized on the opportunity to creatively appeal to customers loosely within the bounds of consumer-intended policy. Companies like Exxon with a history in bioengineering began using microorganisms to manufacture traditional petroplastics, such as polypropylene. In this instance, the beginning of life allows the regime to divert petroleum to the automobile industry, where margins comparable, while at the end of life, creating the same magnitude of environmental damage. These materials have only gained popularity since, and no considerable political or social movements have been made against them, due to the difficulty associated with doing so. Standards and

certifications show a glimmer of hope for the future of this interaction, but are slow to evolve, often following larger incidents.

Restricting Plastic Films and Packaging

Plastic films, in particular bags and straws, are some of the first to gain widespread media as a result of regional/national bans and fees for using these materials. Such policy has recently gained traction in the US landscape, due to their massive accumulation in many coastal counties, including my own, Suffolk County, NY. Suffolk is a particular interest because it was the first region to pass a polystyrene ban following the unfortunate fate of the Mobro 4000, a trash barge packed with Suffolk's polystyrene that could not port for over six months in 1987. Less than 5 years after the policy was enacted, it was repealed, facing scrutiny from the state on the grounds that it lacked an environmental justification statement (Martinelli, 2018). 30 years later, polystyrene, along with plastic straws, has finally been banned in an effort to depollute Suffolk County's surrounding bodies of water (Rassiger, 2019).

Plastic straw bans, like plastic bag bans, have grown more popular than polystyrene bans through popular culture in the last 5 years alone; however, policy restricting the use of individual petroplastic items is actually more supportive of the incumbent regime than the niche in several ways:

1. The removal of these items from the waste stream has created boastful data, such as the end to the ocean pollution that result from the 200 billion straws used annually by Americans; however, plastic straws account for only .025% of the 8 million tons of plastic that reach our oceans each year (Gibbens,

2019). In reality, petroplastic lobbyists have convinced more states to enact policy banning plastic bag restrictions than to actually ban them (currently 14- 8) (SRF, 2019).

2. The turn away from these goods has allowed the manufacturers of the incumbent regime more room to innovate, as above. Due to the unpopularity of paper straws, plastic manufacturers created more appealing lids, which utilize the same material as the straw and often even more of it. Similarly, plastic resuable bags are encouraged at stores; however, it is likely they too will end up in a landfill.
3. The limitations have paper help the incumbent regime to support the aforementioned results and denounce a shift to paper for its own betterment. A temporary shift to paper-based products would be significantly decrease pollution and increase the shift to a circular economy through its composability and advancements in methane capture at landfill facilities in the last decade.

Next Steps

As I continue my own innovation in plastic packaging, I will continue to inform myself holistically of the victories and pitfall to ensure my own work in technology and/or policy does not create unintended consequences such as those above. More specifically, I will revisit my pursuit of a Virginia policy to enable polystyrene and other plastic bans, as well as the development of novel biopolymers for use in consumer packaging and films.

My sociopolitical analyses will proceed along one (or more) of the following topics:

- Successful cases in history in which industry has been incentivized has contributed to the circular ST of the plastics industry;
- How a shift away from consumer-focused sustainable plastic policy can promote alignment of interests and outcomes to reduce pushback from the incumbent regime
- How the the global waste industry's lack of coordination, provoked by the China Sword Policy, can be calmed and improved through circular innovations;
- The more pressing need for circularity in underdeveloped nations.

References

A brief history of how plastic straws took over the world. (2019, January 2). Environment. https://www.nationalgeographic.com/environment/2018/07/news-plastic-drinking-straw-history-ban/

A whopping 91% of plastic isn't recycled. (2018, December 20). National Geographic News. https://www.nationalgeographic.com/news/2017/07/plastic-produced-recycling-waste-ocean-trash-debris-environment/

Allwood, J. M. (2014). Chapter 30 - Squaring the Circular Economy: The Role of Recycling within a Hierarchy of Material Management Strategies. In E. Worrell & M. A. Reuter (Eds.), *Handbook of Recycling* (pp. 445–477). Elsevier. https://doi.org/10.1016/B978-0-12-396459-5.00030-1

China's overall paper imports dropped another 39% last year. (2020, January 28). *Resource Recycling News*. https://resource-recycling.com/recycling/2020/01/28/chinas-overall-paper-imports-dropped-another-39-last-year/

EUBIO_Admin. (n.d.). Oxo-Degradables. *European Bioplastics e.V.* Retrieved November 3, 2020, from https://www.european-bioplastics.org/bioplastics/standards/oxo-degradables/

Hess, D. J. (2014). Sustainability transitions: A political coalition perspective. *Research Policy*, *43*(2), 278–283. https://doi.org/10.1016/j.respol.2013.10.008

Http://www.geocities.com/RainForest/3621/BOULDING.HTM. (n.d.). 8.

Martinelli, K. (2018, October 9). *Is the 30-Year-Long Styrofoam War Nearing Its End?* JSTOR Daily. https://daily.jstor.org/is-the-30-year-long-styrofoam-war-nearing-its-end/

Policies for Bioplastics in the Context of a Bioeconomy (OECD Science, Technology and Industry Policy Papers No. 10). (2013). https://doi.org/10.1787/5k3xpf9rrw6d-en

Pontoni, F., & Bruschi, I. (n.d.). *Sustainable consumption: A multi-level perspective of a systematic transition*. 60.

Suffolk County's Plastics Ban: What Your Business Needs to Know ⋆ Campolo, Middleton & McCormick, LLP. (2019, May 8). Campolo, Middleton & McCormick, LLP. https://cmmllp.com/suffolk-countys-plastics-ban-what-your-business-needs-to-know/

The Latest Plastic Bag Laws and Maps. (n.d.). Surfrider Foundation. Retrieved November 3, 2020, from https://www.surfrider.org/coastal-blog/entry/the-latest-plastic-bag-laws-and-maps

US EPA, O. (2017a, September 7). *Containers and Packaging: Product-Specific Data* [Data and Tools]. US EPA. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/containers-and-packaging-product-specific-data

US EPA, O. (2017b, October 2). *National Overview: Facts and Figures on Materials, Wastes and Recycling* [Overviews and Factsheets]. US EPA. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

US paper recycling rate drops slightly. (2020, May 19). *Resource Recycling News*. https://resource-recycling.com/recycling/2020/05/19/us-paper-recycling-rate-drops-slightly/