D TERM 2024

Viability of Sustainable Business models

A Case Study of a Sustainable Delivery Service in Berlin

Team Members:

Gregoire Brougher

Phillip Cass

Tim Klein

Adam Osgood

Advisors:

Prof. Gizem Arslan

Prof. Sarah Stanlick

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

Abstract

Plastic pollution is a growing problem. This is, in part, due to unsustainable business practices at every stage of the process – from manufacturing to packing to delivery. By switching to sustainable business practices, we may be able to minimize plastic pollution. This paper aims to evaluate the feasibility of a sustainable grocery delivery company in a competitive economic landscape. Using data from a sustainable delivery company, we calculated costs associated with reusable food containers, compared the CO2 emissions of various delivery methods, and analyzed customer feedback. This gave us an understanding of the high operating costs and consumer mistrust faced by sustainable companies. We found that reusable packaging can be economically advantageous if companies enact systems to reduce excess cost. Analysis of our data suggests these changes are much easier to implement as a well-established company with a large customer base rather than a startup. We also found that delivery e-bikes are viable in a city, but an alternative is required to expand to suburban or rural areas. The main barrier to economic viability for a sustainable company is establishing the infrastructure required to reduce costs associated with sustainable practices, improve consumer understanding of their system, and plan for scalability. This suggests that public efforts should focus more on fighting greenwashing or building systems to help established companies make a change towards sustainability.

Acknowledgments

Prof. Gizem Arslan

Prof. Katherine Foo

Patrick Middeke

Prof. Sarah Stanlick

Special Thanks to our Sponsor: Alpakas Technologies GmbH

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Sustainable Delivery Services and their Challenges

As the world continues to develop, our actions are becoming less sustainable. CO2-induced climate change is progressing rapidly. More Plastic waste is being produced than ever before. This waste enters our ecosystems, causing damage to them and to our health.

The global economic structure is responsible for much of this. It incentivizes a race to the bottom where corporations overlook environmental concerns. The effects of this can be seen in the research done by Our World in Data, figure 1, with the exponential growth of plastic production.[1] Fortunately, some companies are making an effort to be more sustainable. In order to succeed as sustainable businesses, these companies need to overcome economic, political, and societal obstacles.

We partnered with a sustainable company, Alpakas. We used the data available to us through this partnership to assess elements of Alpakas and apply what we learned to other sustainable businesses. In this report, we researched specific economic, political, and societal issues that a sustainable company may encounter and possible solutions. We created calculators to measure the economic consequences of using reusable packaging and how cost-effective it is to use zero-emission vehicles. We also analyzed customer feedback from Alpakas to better understand customer attitudes toward a sustainable company.

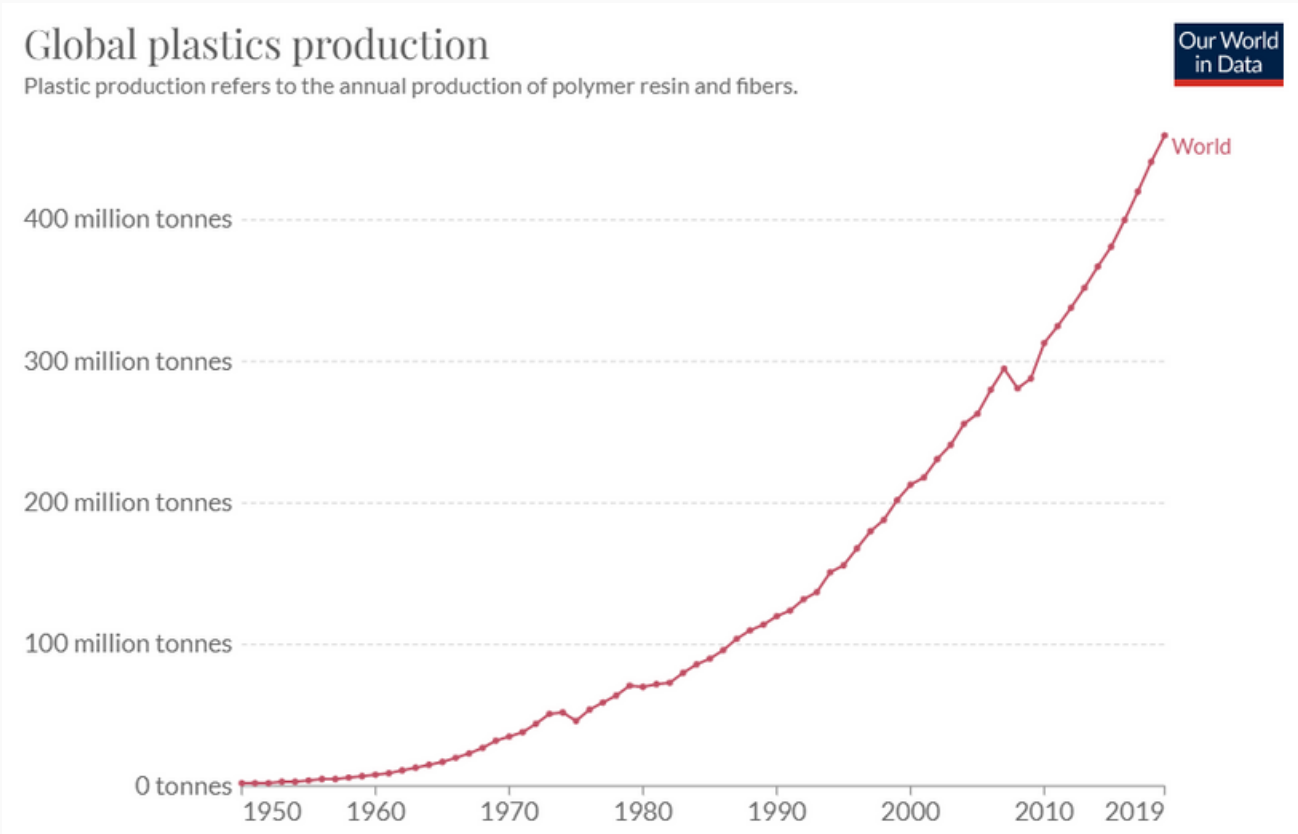

Figure 1: Graph of the annual production of plastics

Background

Introduction

Plastic waste is an ongoing problem that damages shared ecosystems and causes harm to individuals. Due to the nature of competition and attempts to lower prices, sustainable businesses trying to fix this problem can face an uphill battle. Additionally, attempts by some companies to "Greenwash" themselves have made it difficult for truly sustainable businesses to effectively communicate sustainability efforts to these now distrustful consumers. However, there is hope for these businesses. Consumers are beginning to prioritize environmental costs over monetary costs when choosing which products to purchase.

Plastic Waste and Where It Ends Its Life

Plastic waste often finds its way to the ocean through waterways, natural and manmade. A study by Borrelle et al. estimated that 11% of plastic waste ends up in the ocean. This study places the mass of plastic waste that entered the ocean in 2016 alone at 19–23 million metric tons, meaning that the total amount of plastic waste produced in that year was ~200 million metric tons.[2] While recycling plastic does reduce pollution and emissions, most plastics can only be recycled a few times. In addition, plastics are often downcycled rather than recycled, meaning they are made into lower-quality products. According to Akshat Jain's report PLASTIC RECYCLING: DECODED, Only 9 percent of plastics produced globally are recycled, the remainder being landfilled, incinerated for energy, or otherwise discarded. Most plastics that are recycled end up in a landfill, or as litter, by the end of their life.[3]

Impact on Animals and Human Health

Marine plastic debris causes many problems in ocean ecosystems. Macroplastics, plastics larger than 5mm in diameter, which can include plastic 6-pack rings and discarded fishing nets, are an entanglement and strangulation hazard for marine life. Microplastics, plastics smaller than 5mm in diameter, can find their way into the digestive tracts of marine animals. NOAA states that this causes health issues from physical blockage to decreased immune response.[4] The plastics consumed by fish build up in their bodies to then be absorbed by the people and other animals which eat them. While it is difficult to find an actual number for how much microplastic the average person consumes, there are other ways to see how much microplastic exposure we face. A US study by Thompson, Moore, vom Saal, & Swan found that 80 percent of babies had measurable exposure to microplastics, as measured through phthalate metabolites and BPA.[5] Many plastics are carcinogens, which increase an individual's chance of developing certain cancers. Certain plastics, such as Poly-Vinyl Chloride, cause injury to the liver. Plastic exposure is also known to cause problems in the pituitary gland, which regulates growth, and harms reproductive health.[5]

A Case for Sustainable Business

A company, in order to exist, must make money, and they make their money from the perceived value of their products. Many companies achieve this by creating their goods and services for the lowest price and charging customers enough to make a profit. As stated in the journal article Sustainable value creation through business models: The what, the who and the how, value can also be created through customer perception; a company that is more appealing to a customer can charge more for a similar product than others.[6] With the current trends in pollution and carbon emissions, sustainability adds some value to a product in the minds of many consumers.[6] The market must shift to sustainable practices, as unsustainable businesses, by definition, cannot last forever.

Many businesses are moving towards sustainability in order to secure their future and the future of our world, as a way to increase their income while also looking good to the public, or both.[7]

Background

There is a push by consumers for businesses to become more sustainable, but there is no accepted definition of what a sustainable business is. There are many companies striving for sustainability, but since there are so many different factors to take into account and so many ways to define sustainability, it is a complicated issue to address.[7]

Challenges of Being a Sustainable Business

Private Market Competition

Unfortunately, there still exist lower cost alternatives that do not focus on being sustainable meaning sustainably minded businesses have to not only compete with the other sustainable options at a similar price range but cheaper alternatives that are not sustainable. An example of this can be seen in figure 2.[8] Using the straws as an example it can be seen that the sustainable alternative can be 4 times more expensive than the plastic alternative. The increased cost and the abundance of competition are especially difficult for environmentally friendly startups in the past due to a less sustainably minded consumer population.

Consumer Perception

This has changed though during recent years with roughly 80% of consumers saying that they consider environmental impact as a consideration when choosing products,[9] according to a National Geographic article by Sarah Gibbons. This common interest among consumers to shop "sustainably" has had an effect on private companies and has pushed the market towards a sustainable mindset. The increased understanding of a sustainable model has driven operating costs down and has allowed private businesses that are inherently sustainable to maximize profits. This along with analysts saying that as more corporations are becoming more sustainable due to government subsidies and public interest, other companies will be forced to follow which may create a "sustainable revolution" within the private sector.

Greenwashing

Sustainability certifications are quite valuable to private companies. They are an easy way to communicate to consumers that the company is sustainable and the company is not "greenwashing." Greenwashing is when a company falsely claims to be environmentally friendly in order to garner customers.[9] Even though they can have a positive impact on consumer perception these certifications can be expensive to qualify for. This is why it is important to educate your customers on the importance of being a sustainable company and more specifically being conscious of how much waste like plastic can harm our environment and our health.

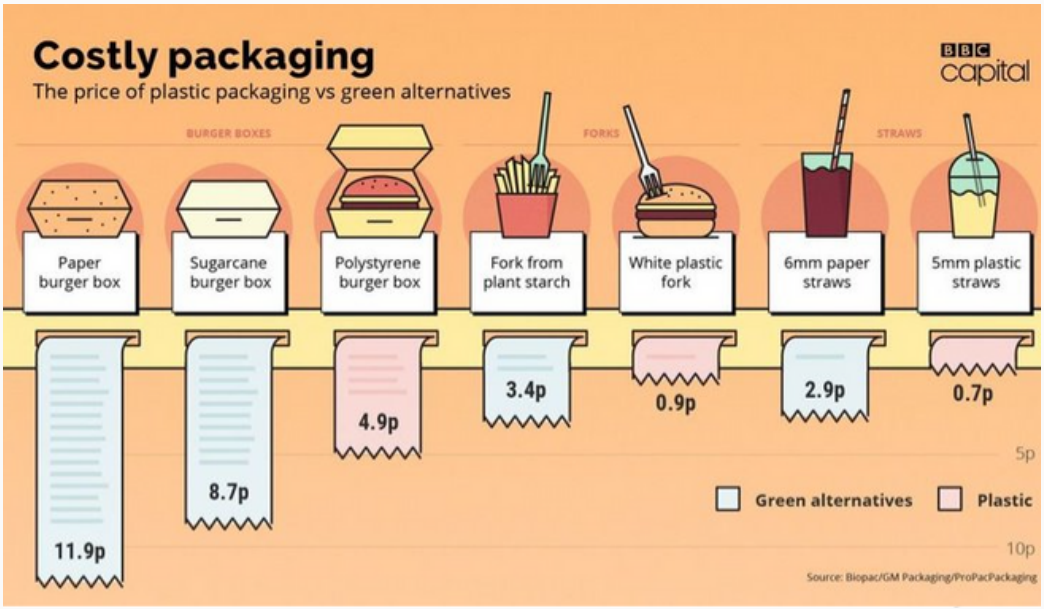

Figure 2: Cost Comparison of sustainable and unsustainable packaging

Background

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Sustainable Model Difficulties

These sustainable models are very difficult to apply to seemingly environmentally friendly practices. For example, the Cradle to Cradle model which requires that all raw materials are reused would seemingly cover a process that reuses glass jars as containers for a food delivery company.[10] That process, however, would not necessarily fall under a certification like cradle-to-cradle, because at some point the jars would no longer be reusable and are difficult to turn into other items without waste.[11] This is why the cost of being honestly sustainable is expensive and reduces the competitiveness of sustainable companies.

Impact Assessment

Measurement Standards

As mentioned previously, plastic and CO2 emissions have a lot of negative effects. This means that it is quite important for a company to be able to measure how much plastic and CO2 they are producing. When it comes to CO2 emissions there exist outside consulting companies that can calculate CO2 emissions produced by a company. Companies like PERSFONI have created software that uses operations data and calculates CO2 emissions on a daily basis.[12] These measurements mean nothing without a consistent understanding of what amount of CO2 emissions is desirable.

This is where the Greenhouse Gas corporate standard comes in. The standard defines how to measure and identify sources of pollution. An illustration of this standard sourced from RISE can be seen in figure 4.[13] Interestingly the standard covers not just the direct outputs from the company, but also emissions from the transportation of products and resources.[12] Plastic, on the other hand, is more directly dependent on the business. For example, plastic-free companies can use a plastic counter that shows the amount of plastic saved through the use of their product or service. A plastic counter is a good way to show your customers firsthand how they are doing better for the environment and reinforces the value proposition of a specialized service. It can show that even though the service might be more expensive than unsustainable options there are greater things at play that rationalize the increased cost in the mind of the customer.

Certification Standards Sustainable

Certifications and assessments are a good way for companies to verify as well as market their sustainable efforts. A good example of this is the B Corporation impact assessment. This is an outside group that will ask companies questions in order to assess their environmental, social, and governance (ESG) procedures.[14] The B Corporation defines ESG as "a collection of corporate performance evaluation criteria that assess the robustness of a company's governance mechanisms and its ability to effectively manage its environmental and social impacts".[14] Assessments like the B impact assessment allow companies large and small to understand their overall effect not only on the planet but on their workers.

Figure 3: Consumer greenwashing perspective

Background

This means that using the resulting ratings they can either make changes to fulfill the requirements or take the rating as a badge of honor that adds value to their product or services.

Opportunities to Standardize Assessment of Sustainability

Much of the movement toward sustainability is being held back by poor standards. These standards can prevent companies from communicating their honest efforts and allow others to present themselves disingenuously. With more research on improving these standards, the increasing number of sustainable-minded consumers could more effectively determine where to spend their money. This would in turn lead to stronger incentives toward sustainability. The ensuing rise in sustainable business practices could allow us, as a society, to mitigate and repair the damages presented by plastics to our ecosystems and our bodies.

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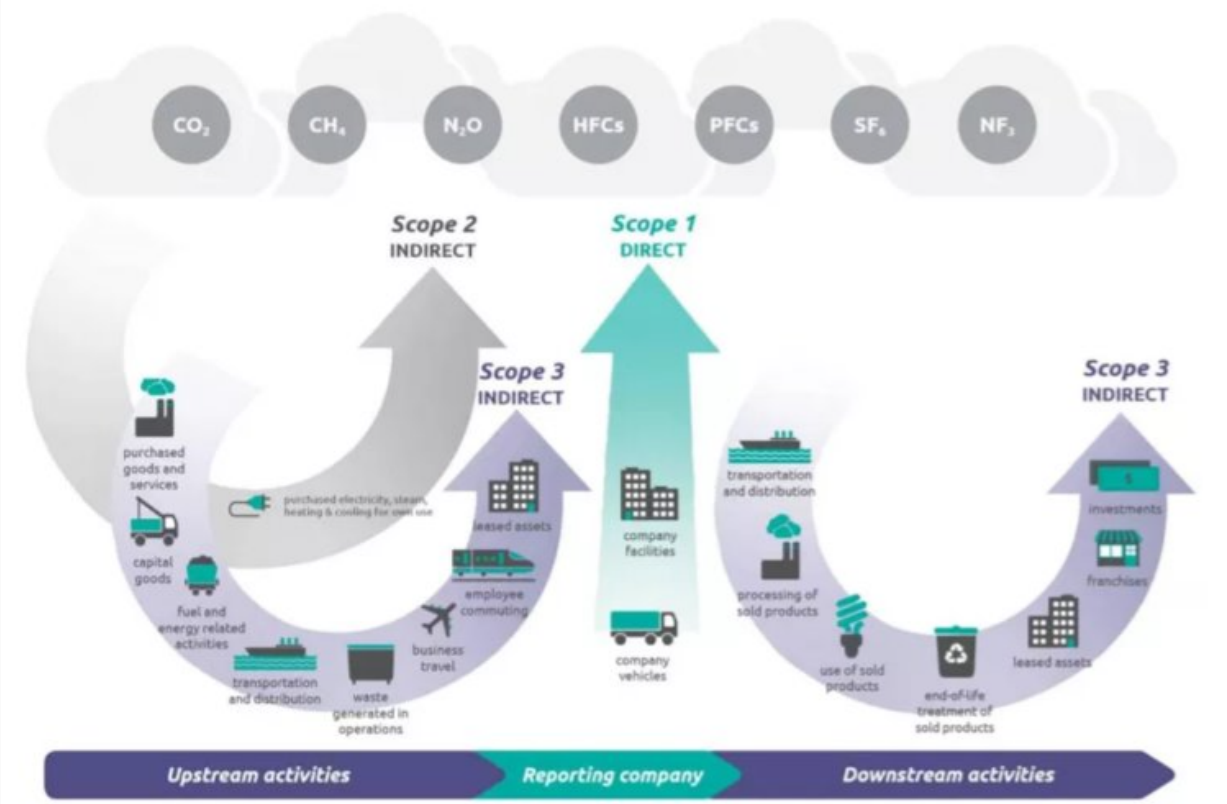

Figure 4: Diagram showing direct (scope 1) and indirect (scope 3) sources of CO2 that a company is responsible for

Methods

Emissions Calculator

We wrote up a framework in Excel for a customizable emissions counter that looks at several aspects of a delivery vehicle. We can compare the amount of CO2 emitted if Alpakas were to use gasoline or hybrid vehicles (the type of vehicle is customizable). The equations used to calculate this can be found in table 1. In addition, we researched the carbon emissions of E-bikes. The latter perspective is to understand what impact social and environmental delivery companies have on communities. These also give a perspective on the environmental impact of the potential reduction of traditional grocery stores, if Alpakas and similar companies were to grow. The focus of this research was understanding the CO2 production of Alpakas' delivery methods.

Of note, Alpakas pays extra to get carbon-neutral power to their warehouse where the E-bikes are charged. This means that, unlike the general case with E-bikes, Alpakas' net CO2 emission per mile is zero. The maintenance and repair of the vehicles are not included in this calculation.

Another factor in CO2 emissions other than efficiency is total mileage. Mileage also contributes to wear and tear on vehicles, eventually leading to a replacement, as well as taking up road capacity.

From Alpakas delivery data, we were able to determine the average distance travelled per delivery with their mailman-style delivery routes.

To calculate the corresponding number for a non-delivery service, we obtained data on the number of supermarkets in the corresponding area. From this data, we calculated the average distance from each residence to the nearest grocery store. We made these calculations under the assumption that housing and grocery stores were evenly randomly distributed throughout the delivery area. Because cars have to go on roads and around buildings, we calculate taxicab distance rather than straight line distance. The difference is explained in Figure 5

Table 1: Emissions Calculator Variables and Equations

Variable	Name	Equation
E_i	Emissions unique to each vehicle type (indexed by i) measured in grams of CO2 per kilometer	Input
D_w	Distance Traveled per Week indexed by i weeks	Input
D	Distance Traveled per year	$\sum_{w=1}^{52} D_i$
Output	Resulting output per year of CO2 measured in kg of CO2 separated by vehicle type (indexed by i)	$\frac{(D \cdot E_i)}{1000}$

Methods

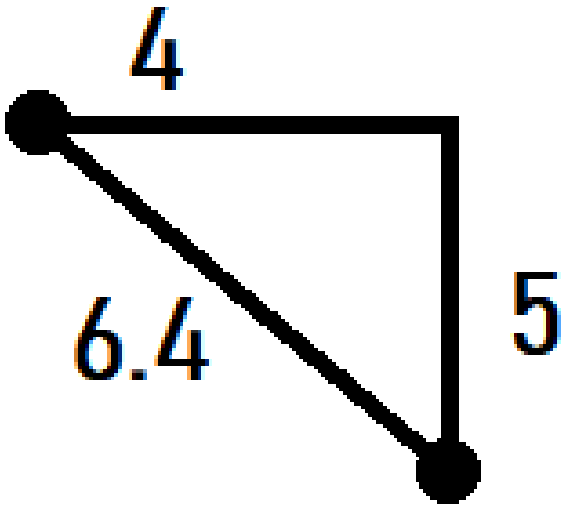

Figure 5: The taxicab distance between these two points is 9 even though the straight line distance is 6.4

Cost Calculator

We have built a framework in Excel that compares the cost of certain types of packaging based on potential short- and long-term reuse. This framework includes the cleaning cost, the initial cost, and any recurring costs associated with each packaging type. It also contains fields for the cost of disposal and a plastic tax (it is worth noting that this plastic tax is paid directly to the EU by the German government, meaning its burden is shared by all taxpayers. We used the same value of €0.80[17] to determine the effect if this tax was applied directly to private businesses). A simple depiction of this calculator can be found in figure 6.

This system determines if a certain container is cost-effective compared to a single-use plastic container, how many times it must be reused to be cost-effective, and how a higher plastic tax may affect this comparison. Non-reusable lids are currently a large cost associated with reusing glass jars. Looking into glass-lidded jars which use gaskets to form a seal and have a reusable lid, we have found that silicone gaskets, as opposed to natural rubber, are reusable, so a fully cleanable and reusable jar is possible.

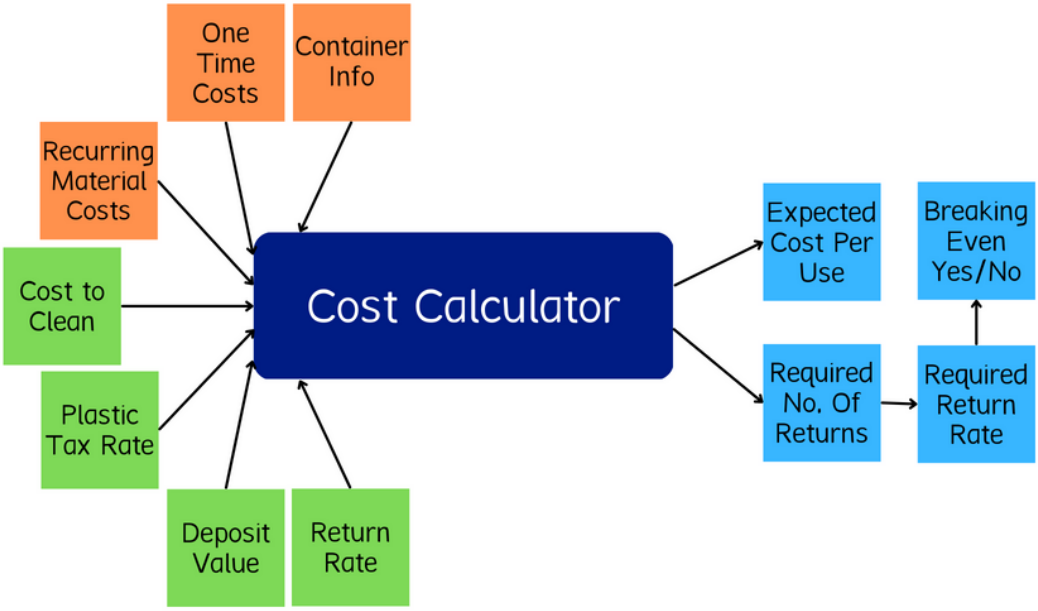

Figure 6: Graphical Depiction of our Cost Calculator

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To calculate the cost per use, the calculator uses the one-time and recurring costs and the number of uses that the package will see in each scenario. These scenarios include: if the container reaches its end of life without being lost or broken, which returns the minimum cost per use; if the container is not returned and Alpakas keeps the deposit, which returns the expected cost per use assuming an unrefunded deposit; and if the container is lost or broken by Alpakas and the deposit has been returned to the customer, which returns the expected cost per use.

These reuse costs are used to determine how many uses would be required for the container to break even in cost with disposable plastic. The cost per use for plastic is simply the cost of the plastic container with the plastic tax added. Some fields of the calculator are more static than others, such as the upfront cost of jars, disposable lid cost, cost of plastic containers, and expected maximum number of uses. These are meant to be entered once and not changed. The fields that are meant to be changed to test different situations include

Table 2: Cost calculator equation table

Variable	Name	Equation
C_0	Cost of the container	Input
D	Deposit	Input
R	Return rate	Input
C_w	Cost to wash	Input
C_d	Cost for disposal	Input
M_r	Maximum amount of reuses	Input
m_a	Minimum cost of single use alternative	$\frac{C_0}{M_r} + C_r$
P_r	Projected number of reuses	$1 + \frac{R}{1-R}$
C_r	Cost to reuse	$C_w + C_d$
J	Cost to reuse with nonrefunded deposit	$\frac{C_0 - D}{P_r} + C_r$
K	Minimum cost per container using maximum possible reuses	$\frac{C_0}{M_r} + C_r$
L	Required number of reuses to compete with single use	$\frac{C_0}{m_a - C_r}$
M	Required return rate to compete with single use	$\frac{L-1}{L}$
N	Required number of reuses to compete with single use with nonrefunded deposit	$\frac{C_0 - D}{m_a - C_r}$
O	Required return rate to compete with single use with nonrefunded deposit	$\frac{N-1}{N}$

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Cost of cleaning, which can be edited to determine how different cleaning methods affect whether the jar breaks even with plastic; Plastic tax, which can be edited to determine what plastic tax would be required to incentivize reusable containers; Expected return rate, which can be edited to determine the expected cost per use and the average lifetime of the jar; Actual return rate, meant to be edited to reflect the actual return rate (obtained via a tracking system) to determine if a jar breaks even with plastic.

The data for the plastic alternatives was an average that was found after visiting many different suppliers. A heavy-duty plastic bag that is meant to carry many groceries is about 0.05 Euro per bag and a produce bag that can be found in grocery stores is about 0.02 Euro per bag. To determine the return rate of the containers, we used data provided by Alpakas on the number of deliveries by week and a list of container returns. The analysis of the data showed that the average number of returns per week was 71.48% of the average number of deliveries. If the return rate could be improved using a container tracking system and/or customer outreach, fully reusable jars would be more economical and sustainable than not only Alpakas' current containers but even single-use plastic. We have also researched alternatives to the jute tote bags and the cotton produce nets that Alpakas currently uses. However, finding alternatives to Alpakas' current bags has been a challenge since most reusable bags available in bulk are different versions of what Alpakas is already using, neither better nor worse when it comes to cost-effectiveness. Currently, Alpakas cannot clean jute bags if they are soiled, and we have researched cleanable alternatives, such as canvas or cotton bags.

Customer Feedback

Customer behavior is important in every industry. To get insights into the attitudes of their customers, Alpakas has a customer feedback form on their app. Through Alpakas, we had access to the 1910 responses. In order to simplify our analysis, we isolated the 119 responses where customers gave ratings under 7/10 stars. Then we read through these responses and sorted them into categories. The categories were as follows: service too expensive, not enough choice available, wrong, not all, or poor quality items received, problems with the delivery, issues with the deposit system, and other complaints. If a response complained about multiple areas, it was counted in each area.

We also averaged the scores of reviews that contained complaints in each category. This was to see if any problems were particularly disliked by the customers regardless of occurrence rate. To verify any interesting findings in that regard, we performed a two tailed t-test. with a desired confidence of 0.05. The null hypothesis used was that all complaint categories had the same average rating.

Tracking Systems

When determining the best way to put a barcode on the jars we looked through the available printing material options for the printer we had available and identified a label type, made primarily of polyester, that worked with our printer that we thought might work well in this situation.

When we first began thinking of ideas for a permanent tracking system for Alpakas' packaging, we suggested etching a barcode onto the glass jars. However, this would require a dedicated machine to do the

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etching, and this would be another step in the manufacturing process. This could cause a bottleneck in the process as well as potential problems so we deemed that barcode etching would not be practical.

Because of this, we decided that printed labels were a better approach. For the software side of the tracking system, we found several companies that could help us understand the methods and challenges associated with a container tracking system. One of them was Topanga, a startup that consults for companies that use reusable packaging. We attended a meeting with the co-founder of Topanga to see how their system may work with Alpakas.

We contacted a separate company to inquire about printing labels. We found that printing our own labels for testing would be impractical and costly, though the printing company had spare labels of the same material that we were planning to have ours printed on. These labels did not have any barcode or QR code printed, so we dropped our original plan to scan the code after each test to using Optical Character

Recognition to test the condition of the labels, and whether they were still readable by a scanning system. For our testing procedure we placed labels in various locations on the jar. This allowed us to see the best location for the labels to increase the chances of the labels surviving Alpakas' washing process. We decided to place the labels along the bottom face of the jar, on the side of the jar, along the lip on the bottom of the jar horizontally and vertically. To properly apply the labels, we ensured the ambient temperature was above 10C when we applied them. We left the labels alone 24 hours after application, giving them time to adhere properly.

We ran three cycles of testing with three types of testing per cycle. These three tests were the dishwashing test, soak test, and shake test in that order. The specifics of each test are shown in figure 7. The reasoning for having the dishwashing test is that the jars need to be washed between every use at Alpakas, and customers regularly wash the jars before returning them, so we needed to replicate this process in our testing to see if the labels can survive. The reason for having the acetic acid and detergent soak test is that many customers decide to wash the containers themselves before they return them for their deposit. They may not all use regular dishwashers, so we made sure to test how the labels would survive being immersed in a vinegar solution for 5 minutes, as well as being immersed in a detergent solution for 5 minutes.

We developed the shake test because the jars will be in contact with each other during transport, and we needed to make sure that the labels would survive the transportation processes. We ran these tests in order, taking notes and photos of the jars to record the state of the labels. We repeated this cycle three times. Our original plan was to repeat the cycle five times to collect enough data, however, after the third cycle we noticed that all the labels were faded and only the bottom labels were the ones left with only two side labels present. Therefore, we saw no reason to continue testing for more than three cycles.

Methods

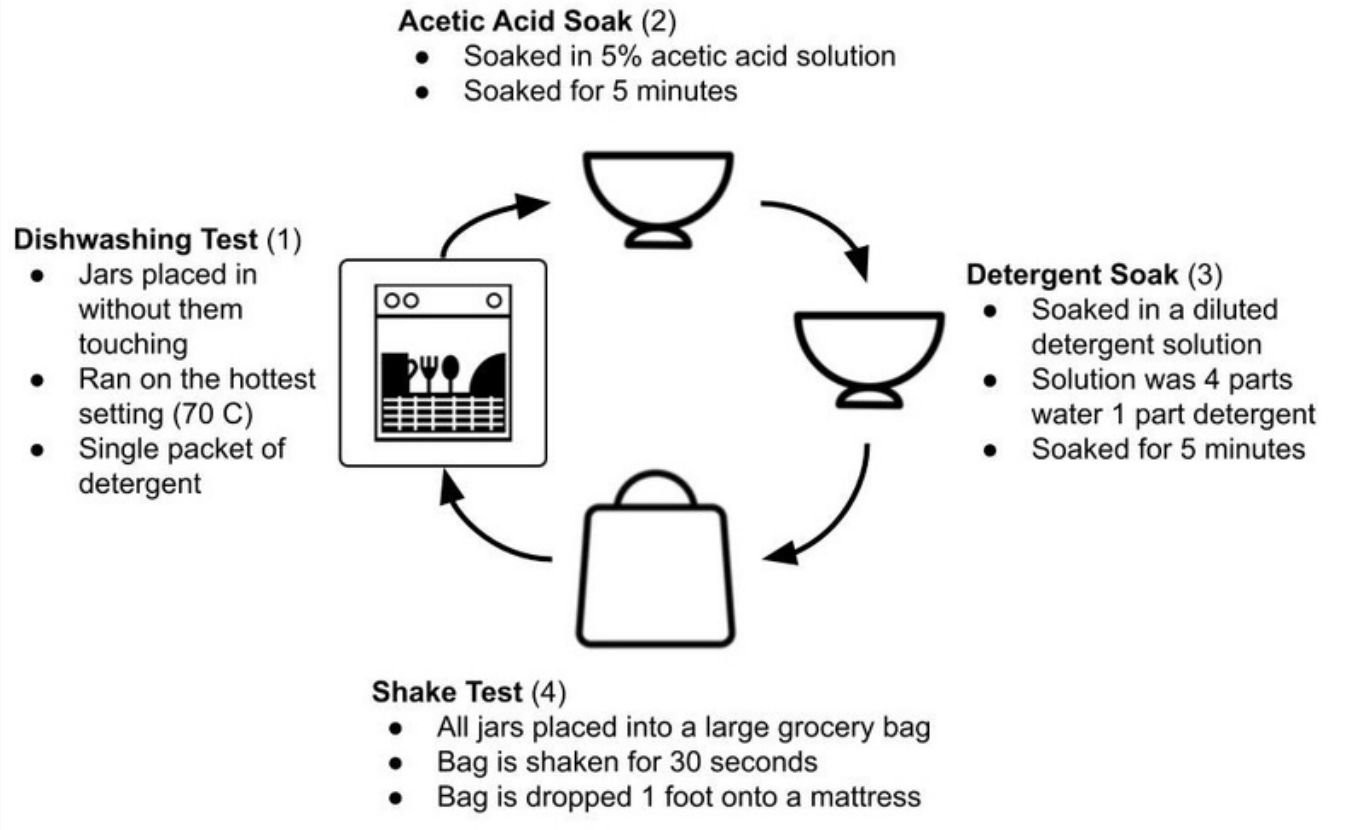

Figure 7: Our testing procedure for the labels and specifics of each test

Findings

Emissions Calculator

When looking at vehicles in a sustainable delivery company, zero emissions vehicles can be a good option. Their usefulness is, however, highly dependent on the areas they are serving. When looking just at emissions it is clear that E-bikes and the E-van are the best option. This is a good thing for Alpakas, because it allows them to market a zero emissions vehicle fleet, but they may not be the best when it comes to usability. We also

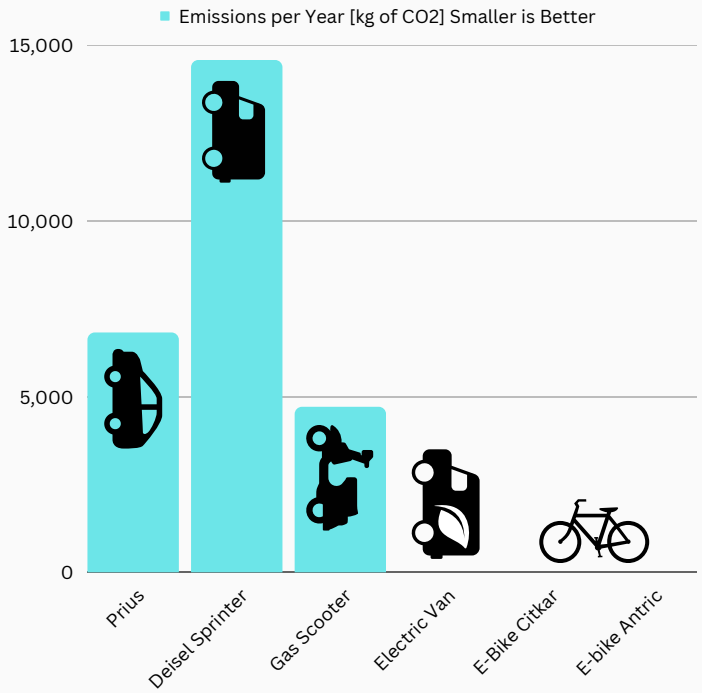

Figure 8: Emissions Comparison Between Vehicle Types

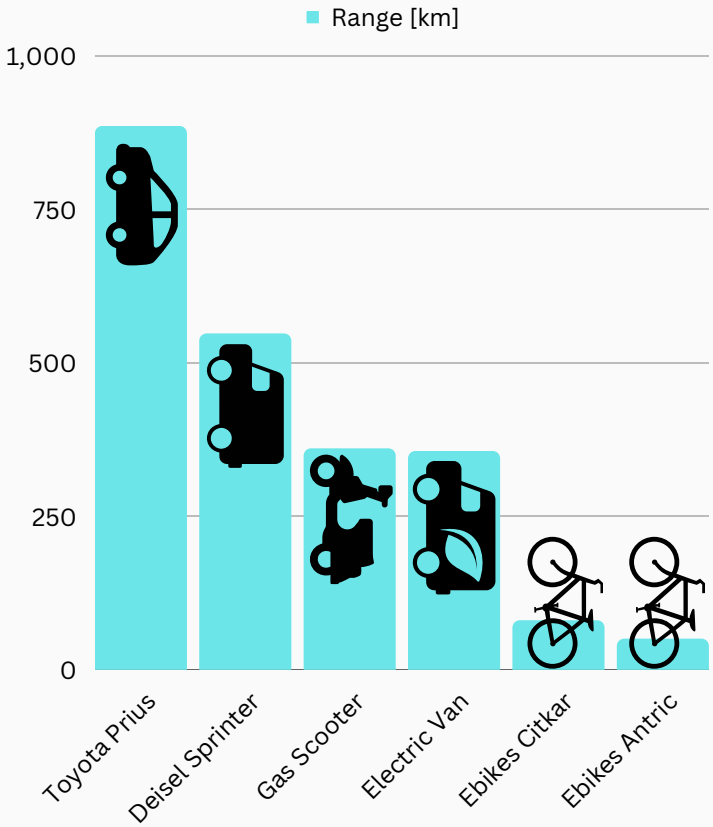

Figure 9 Range Comparison Between Vehicle Types

Figure 10: Carry Capacity Comparison Between Vehicle Types

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looked at other aspects of the vehicles that pertain to delivery driving which included carry capacity and range. When looking at all of the different aspects holistically, for Alpakas right now, the E bikes still make sense due to the fact that they only really serve the city. We did find though if this business model were to be applied to a more rural area, the E bikes seemingly do not make sense. We recommend a hybrid sedan for a couple reasons. Most importantly the emissions of 6815 kg of CO2 per year is considerably less than that of a diesel van which comes in at a staggering 14570 kg of CO2 per year. This brings up the question as to why the E-van is not the best for this application. We found that the considerably less range of 355.5 km[15] means that fewer orders can be shipped per trip as well as the fact that it is difficult and expensive to increase the range when out in the field. This compares to the Hybrid sedan which not only has a considerably greater range of 885 km,[16] but can be easily filled up at any gas station. The competitive capacity, increased range, and low emissions make the hybrid sedan the best option operationally as well as marketing wise when it comes to a sustainable delivery service.

Calculating the average distance between a residence and the closest grocery store lead to some surprising results. We got a result of around 1km. In comparison, even with their milkman delivery routes, Alpakas averaged 5km of driving per delivery.

This means that driving to the nearest in person grocery store is considerably more efficient than their current delivery system.

If a delivery system is to be more efficient in terms of miles driven per customer, it needs to have more warehouses and customers.

In the area served by the e-bikes, there were over 100* grocery stores. If there were more customers in the same area, they would be packed closer together, allowing the delivery routes to be more efficient.

This is important because it shows the ability of a company to be sustainable is dependent on its size. A startup can't afford many warehouses and does not have as many costumers as a well established company. In conclusion these calculators does a few things. Firstly it gives Alpakas the ability to quantify how much CO2 their customers are saving by receiving deliveries from a zero emissions vehicle. Second it was a case study in how to choose vehicles for a sustainable delivery company and clearly shows that vehicle choice is heavily influenced by the area that a company is serving. Finally, the grocery store data shows that delivery companies in comparison to grocery stores. Due to the scope of our analysis and available data we did not look at other scopes of emissions.
More analysis into second and third order emissions may find that a established delivery company may be more sustainable.

Cost Calculator

Exploring the economic challenges or benefits associated with sustainable practices, we found that with the current calculated return rate of 71%, and the current cost to clean, none of the glass jar options break even with plastic. If cleaning were to be moved in house, lowering the cost to clean significantly, the extra small, medium, and large jars with disposable lids break even with plastic if the deposit is not returned. Figures 11 thru 14 show that if the return rate were improved to 90% (the goal of the Topanga tracking system), and cleaning were brought in house, large and

*The exact number is unnecessary and the subject of an NDA

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medium jars with disposable lids would break even with plastic and large and medium fully reusable jars would break even as shown in figure 11, small jars would also break even after 14 uses, which is roughly a 93% return rate). The fully reusable extra small jars pose a challenge because reusable silicone gaskets are only available for the small, medium, and large jars.

The extra small jars would require non-reusable natural rubber seals, which while

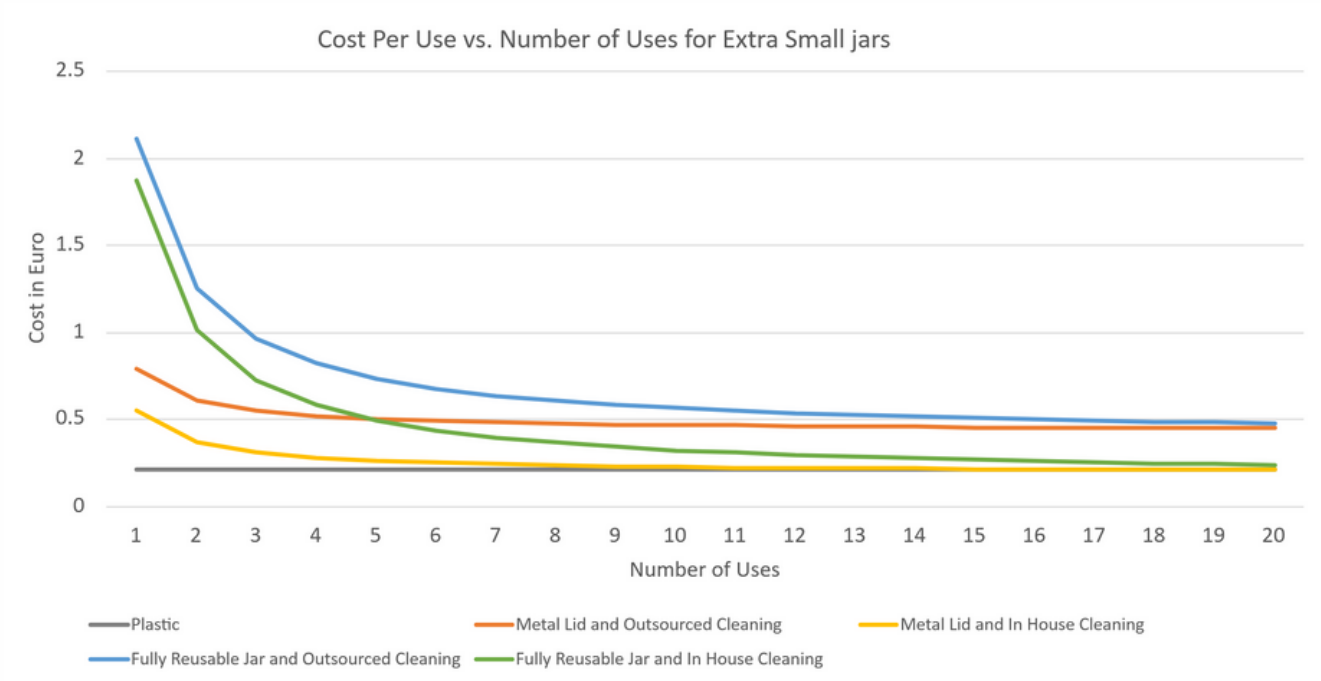

Figure 11: Cost Per Use vs. Number of Uses for Extra Small Jars

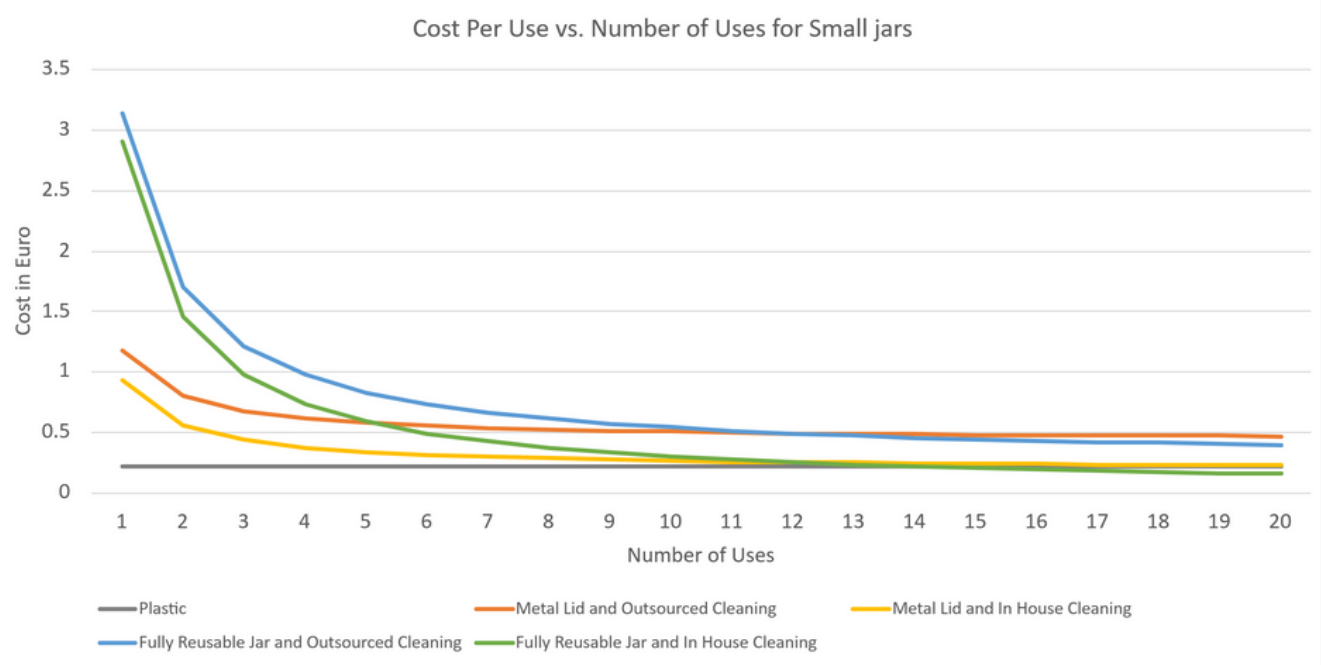

Figure 12: Cost Per Use vs. Number of Uses for Small Jars

Findings

cheaper than the current disposable metal lids, are still a recurring cost and not environmentally sustainable. Silicone gaskets for these jars could be custom ordered, though this would not be cost effective unless ordered in an extremely large quantity.

The cotton bags that Alpakas currently uses are not able to compete with the plastic alternatives that we found. This is because outsourcing the washing process for cotton bags caused them to become too expensive to reuse. If washing was done in house, it may be cheaper than plastic alternatives.

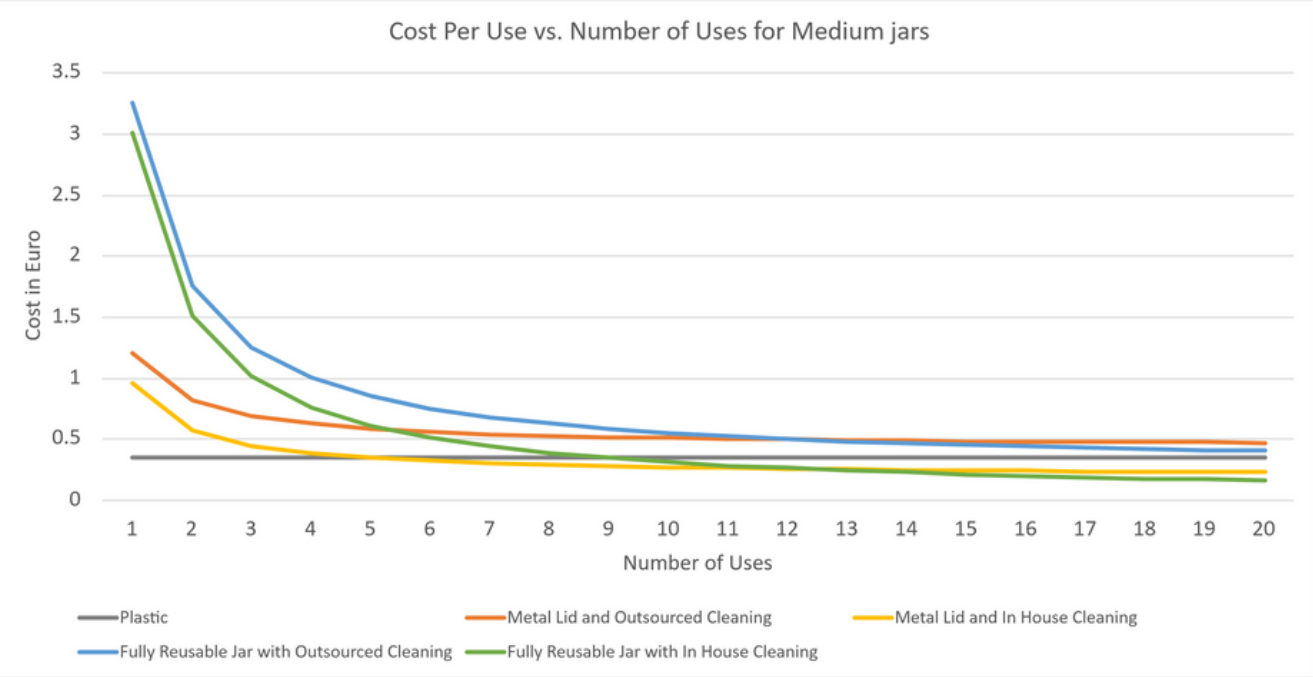

Figure 13: Cost Per Use vs. Number of Uses for Medium Jars

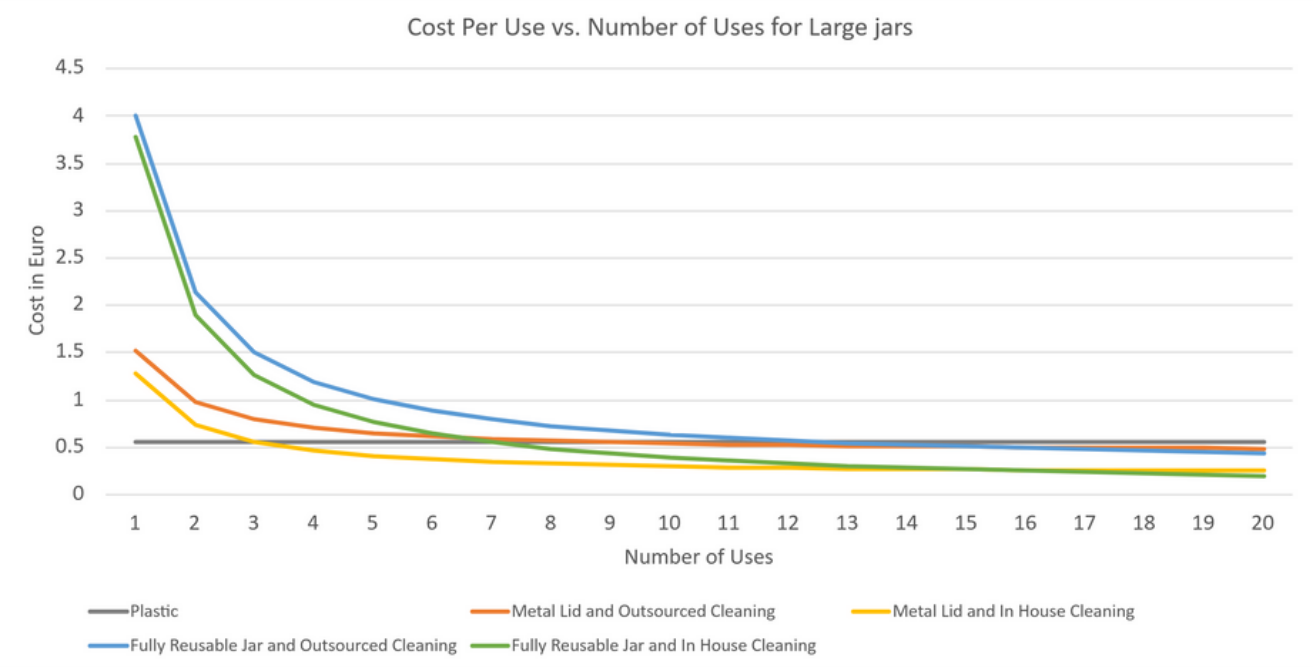

Figure 14: Cost Per Use vs. Number of Uses for Large Jars

Findings

The jute bags are only cheaper than plastic alternatives if the deposit is not returned and the bags are reused at least 9 times, which is an 89% return rate. It is also very hard for the jute bags to compete since they are extremely expensive at €2.97 per bag. The NWPP bag (reusable plastic bag) which is the same size as the jute bag is not able to compete with the alternative plastic bags in any situation due to the washing cost and or the plastic tax. The plastic crates can compete with plastic bags if they are reused 37 times with a return rate of 97% or 25 times with a return rate of 96% if the deposit is not refunded. These crates are held back due to plastic tax (if implemented) and washing costs, though the washing cost could be made lower than €0.01 since the crates would not have to be washed unless they are dirty. A suggestion to Alpakas may be to not use the jute bags and simply have the jars sit freely on the doorsteps, or maybe to use crates instead of bags.

Finding alternative bags for Alpakas was difficult since most reusable bags that are widely used and sold in bulk are the cotton and jute bags that Alpakas is already using.

We were unable to find a suitable replacement for the cotton produce bags, but we found two replacements for the jute bags. One of which is a reusable plastic bag and the other being a plastic crate to carry groceries.

Another challenge on top of a lack of available alternatives is that the plastic tax is too low. The current tax is €0.80 per Kilogram[17] and even if this were passed on to private businesses, when dealing with plastic bags, the tax is simply too low to allow Alpakas' bags to compete with single-use plastic packaging. Our calculator has a field for the mass of the plastic packaging and the overall tax that the plastic would accrue, and we used this to determine that even with no tax, Alpakas' current bags are still the best option. This would require a nearly 90% return rate, however, and an increased plastic tax would decrease this figure. When inputting numbers in the calculator, there are some that we could not obtain, so we used our best estimates of what they could be. The weight for plastic alternatives to bags had to be assumed as the website that provides the alternatives failed to mention the weight of the products. Alpakas' cleaning cost for the alternatives also had to be assumed as we do not know how Alpakas would handle washing alternative bags or if they would even need to wash them. The washing cost for the cotton bags was assumed, as Alpakas did not have accurate figures. The return rates provided by Alpakas were very rough estimates and the return rates for alternative bags are speculative. The cost for the plastic single-use alternatives is the average of many different suppliers.
The container return rate that was given by Alpakas was a very rough estimate and for that reason, we calculated a more accurate return rate.

Although we calculated a more accurate return rate, it is only used to determine whether reusable containers are currently breaking even with plastic. This return rate of 71.48% is a rough estimate, based on the data provided by Alpakas. We did not have access to data on what containers were sent out with orders, only the number of orders in each week. We were given data on which containers were in each deposit return. Without similar data on the orders, we could not calculate a true container

Findings

return rate. Instead, we found the number of container returns in each week and compared that to the number of orders for each week. These values were plotted in Fig. 15, displaying that the number of returns was consistently below the number of orders. This does not consider that containers are often not returned in the same week, as customers may not use the contents within that time. Containers from the same order may also be returned at different times.

However, looking at the average number of orders per week and the average number of returns, we can achieve a rough estimate of the return rate, which comes out to 71.48%. Using a cost calculator is important for a sustainable company. A cost calculator allows the company to determine how sustainable packaging compares to cheaper and less sustainable alternatives. This allows the company to pick more cost-effective packaging methods. In a world where sustainable companies are financially at a disadvantage to less sustainable ones, finding a cost-effective and long-term packaging solution could be the difference between success and failure.

Addressing our first research question, we found that a plastic tax is not necessarily required for reusable jars to be more cost-effective, provided a company has the proper infrastructure to lower cleaning costs and improve return rates. This is cost prohibitive for many smaller companies, creating an obstacle for those companies to use sustainable business practices. Though an increased plastic tax would improve the savings of reusable packaging, focus should be placed on making the infrastructure required to support reusable packaging more easily accessible, especially for startups.

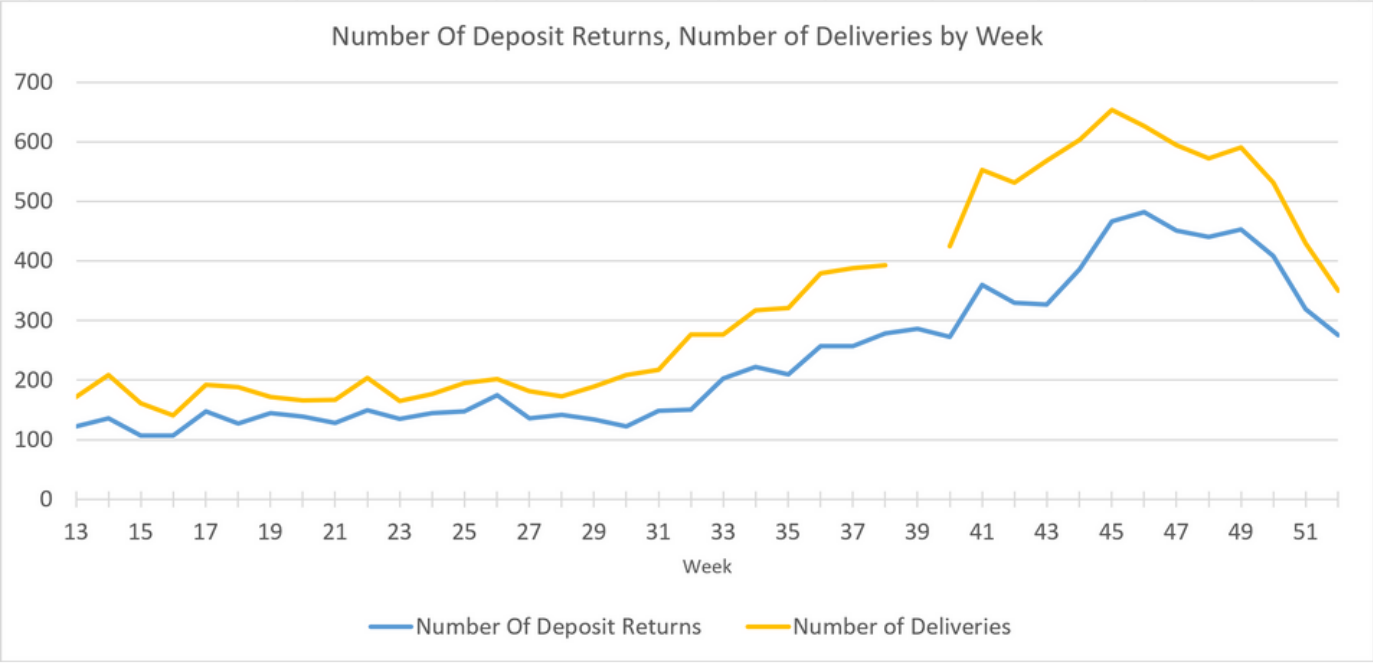

Figure 15: Number of Deposit Returns and Deliveries by Week

Findings

Customer Feedback

Another barrier to sustainable business is costumer adoption, so we analyzed their complaints. In our analysis , we found the following categories: cost, choice available, quality of products, delivery problems, and deposit system issues.

Figure 16 shows the distribution of complaints by category. We see that Poor quality or missing items was the number one complaint category. This was most likely due to customers not appreciating or understanding substitutions. The second most common complaint category was complaints about the deposit system, at 18% of complaints. Table x shows the average rating of complaints from each category. The table shows a difference in averages. Among the 23 complaints about deposit related problems, the average rating was lower than among all the complaints in general. However, the t-test showed this was not statistically significant at the p <0.05 level. The difference between total complaints and specifically missing deposit complaints was also not statistically significant.

However, among the deposit-related complaints, several customers directly suggested implementing a better tracking system. Of those that did not, complaints included missing deposits, confusion over deposits, and not knowing what outstanding deposits they had. All of these problems can be solved by the implementation of a tracking system. In the Tracking System subsection, we talk more concretely about the effect that such a tracking system can have on customer behavior.

Table 3: average score of negative reviews by complaint type

Complaint type	average rating
Cost	4.8
Available Choice	5.0
Poor Quality or Missing	4.0
Delivery	4.3
Deposit System (all)	4.0
Deposit System (specifically missing/wrong)	3.5
Other	5.1
All/Total	4.3

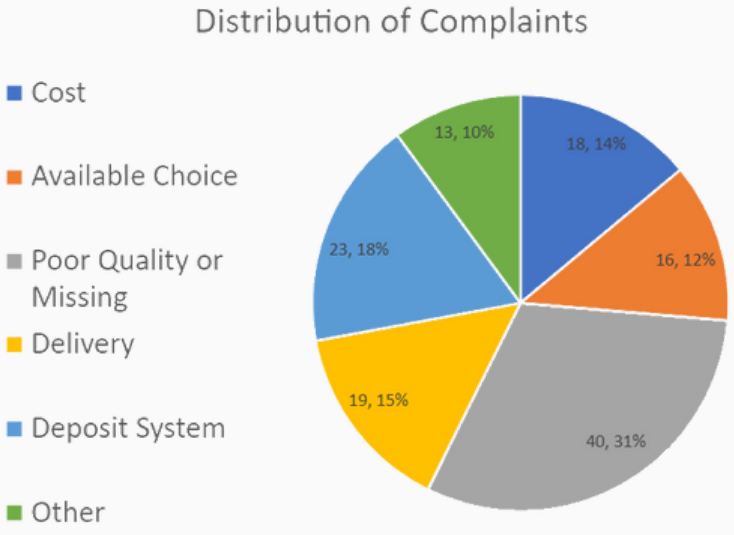

Figure 16: distribution of complaints, by category, in negative reviews

Findings

Tracking System

Customer behavior plays a very important role in the economic success of reusable packaging. If customers don't return the reusable packaging then the company is unable to reuse the packaging, however, a tracking system would help improve return rates.

After performing our test, we found out that the soak and shake test had little to no effect on the labels. This can be seen in figure 17 and figure 19 since after the soak and shake test, the condition of the labels does not change. However, the dishwashing test had a significant effect on the label. Many labels fell off after the first wash and after the second wash, most labels faded as shown in our results.

Overall, our research concluded that labels placed on the bottom of the jar have an 83% chance of surviving the washing process. The fading of the labels seen in figure 18 is also shown in our results, Figures 17 A and B, after the second dishwashing test. The cause of this may be due to what the printing material was made of. The print used on the labels that were tested most likely would not have lasted two more washes before becoming unreadable. This means that if Alpakas wants to have a tracking system in the future, they would need to place barcode labels on the bottom of their jar with some alternative for the ink used in the printing of the labels that would survive the washing process.

Using the results from the label testing and the insights from an interview with one of the co-founders of Topanga, we wrote two briefs for Alpakas regarding suggestions for a tracking system.

From the Topanga interview, we heard about their experience implementing a tracking system for a separate plastic-free grocery service. With it, they were able to send push notification reminders, use late

Figure 17.A: Results from the label testing for jar 1, 2, and 3

Findings

fees, and let customers know what packaging they were still in possession of. With this, they were able to get short term packaging return rates over 90%. This was without using deposits as well.

Without a tracking system, there is a decrease in return rates of packaging material resulting in reusable packaging becoming a financial burden. This is because reusable packaging is more expensive than single-use packaging and without being able to get multiple uses out of reusable packaging material the company will lose money.

When a company is unable to identify which customers have specific packaging items, it makes it difficult to target customers to return their packaging items. This means a lower return rate on packaging items which means less reuse of packaging materials. A tracking system also aids in the accuracy of the deposit system which increases return rates. There is an ideal return rate required for reusable packaging to become cheaper than single-use alternatives, ranging from 65% to 95% depending on the size of the packaging. With a tracking system, customer behavior can be changed to increase return rates to reach the ideal return rate.

Figure 18: Labels on jar 1 before label testing (left) and after label testing (right)

Figure 17.B: Results from the label testing for jar 4, 5, and 6

Conclusion

Current business practices put public health at risk. This risk is only getting worse as large unsustainable companies crowd out the competition and race to the bottom. The circular economy, where products are designed to be reused rather than thrown away, is a proposed sustainable business model. It comes with many obstacles over the traditional, single-use model. These obstacles range from direct monetary costs to consumer behaviors, to unforeseen consequences. We worked with Alpakas, a company that subscribes to a circular economy philosophy, to research possible solutions to some of the obstacles that a sustainable business may face.

During our research, we identified three types of obstacles that sustainable businesses may encounter. These obstacles are economic, political, or societal.

In addressing the economic obstacles, we found that reusable packaging can be more cost-effective than single-use disposable plastic, provided a company has the proper infrastructure to lower cleaning costs and increase the return rate. The required infrastructure is expensive, however, and may be cost prohibitive for some businesses. In addition, a plastic tax is not needed for reusable containers to be cheaper, though a plastic tax that actually affects private companies would increase the monetary savings from reusable containers, making reuse more attractive to businesses.

The return rate depends on customer behavior, which is not directly under the control of any company. In an effort to better understand customer behavior in this regard, we analyzed customer feedback available to us. We found that customers particularly disliked not receiving their deposits back, or at least, the perception that they did not. Additionally

A deposit tracking system can alleviate these concerns. It allows a company to better communicate to customers as well as keep track of things on their own end. Using these tools, short term return rates of over 90% are achievable, from a baseline return rate of 70%.

More than customer engagement, tracking systems require a physical side as well. A label is required to identify specific packaging items. The best way to implement a tracking system for reusable jars is to place barcode labels with a permanent print on the bottom of the jars. This is the easiest and most cost-effective way to implement a tracking system. Our limitation in our research was our inability to apply this tracking technique to multiple types of packaging items. We were also unable to apply this tracking system in a real-world application. As such, more research in this area is recommended.

When looking at the vehicles that Alpakas uses while creating a system to show how much CO2 there customers are saving we found that the vehicle choice can have a significant impact on a delivery companies process. When we looked at other aspects of the vehicles aside from just emissions we found that the E-bikes that they currently use are a good fit for their current process. However, if they were to expand outside of the city moving towards a fleet of hybrid sedans provide a good combination of emission, range, and carry capacity.

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Supplemental (don't print)

To analyze the customer feedback data, we used a two two-tailed t-tests with α = 0.05. We wanted to see if the deposit related complaints or the missing deposit related complaints were ranked significantly higher or lower than the average complaint. The null hypotheses were that each data set had the same mean.

We checked that the data had similar standard deviations and were normally distributed. Because of confidentiality concerns, the histograms used to check normality are not shown. Table 4 shows about the data and of the results of t-tests. Figure 19 shows the python code we used to calculate t-statistics.

Table 4: Notes about datasets and how they performed in a two-tailed t-test

Dataset	Number of data points	Standard deviation	Degrees of freedom	T-statistic
All complaints	119	1.7	N/A	N/A
Deposit related complaints	23	1.9	140	0.805
Missing Deposit related complaints	15	2.0	132	1.857

```
#calculates the t statistic given the size, mean, and standard deviation of two data sets
def t_statistic(size_1, avg_1, stdev_1, size_2, avg_2, stdev_2):
    #pooled standard deviation
    pooled_stdev = pooled_standard_dev(size_1, stdev_1, size_2, stdev_2)

    #difference in averages between the two data points
    avg_diff = avg_1 - avg_2

    #t statistic
    t_stat = avg_diff / (pooled_stdev*sqrt(1/size_1 + 1/size_2))

    #degrees of freedom
    df = size_1 + size_2 - 2

    print ("t_statistic")
    print (t_stat)

    print ("d_f")
    print (df)

#calculates the pooled standard deviation of two data sets given their size and standard deviation
def pooled_standard_dev (size_1, stdev_1, size_2, stdev_2):
    pooled_variance = (((size_1-1)*(stdev_1**2))+((size_2-1)*(stdev_2**2)))/(size_1+size_2 - 2)
    return sqrt(pooled_variance)
```

Figure 19: T-statistic code (Python3)

Supplemental (don't print)

To determine the average distance between residences and the closest grocery store, we used a simulation. To make this simulation, we used data obtained from Alpakas about delivery radius and number of supermarkets existing in said radius.

The simulation worked by randomly distributing a number of stores in a circular area of certain radius. Then a random point in said circle was chosen and the taxicab distance to the nearest grocery store was calculated. This test was repeated 10,000 times and the results averaged. Figure3 20-21 show the Python3 code we used and the results obtained

```
#returns the taxicab distance between two cartesian points by adding the absolute value of their x and y distances
def dist_between_points_taxicab(point1, point2):
    return (abs(point1[0]-point2[0]) + abs(point1[1]-point2[1]))

#randomly distributes num_stores points across a circular area of radius circle_radius
def generate_points(num_stores, circle_radius):
    stores = []

    for i in range(num_stores):
        points.append (generate_point(circle_radius))

    return points

#generates a random point in a circular area of radius circle_radius
def generate_point(circle_radius):

    #tuple, first entry is an angle from 0 to 2*pi, second entry is a distance from the center
        #the second entry scales random.random() to the half power.  This keeps it as a range from 0 to 1
        #while biasing towards higher numbers in a way that accounts for the fact that circumference
            #increases with radius,
            #i.e. if it was an equal distribution, more points would be crowded around the center
    new_point = (random.random()*2*3.14159265, sqrt(random.random())*circle_radius)

    #from polar to rectangular coordinates, then return
    return (new_point[1]*cos(new_point[0]), new_point[1]*sin(new_point[0]))
```

Figure 20.A: Grocery store distance simulation code

Supplemental (don't print)

```
#returns the taxicab distance between two cartesian points by adding the absolute value of their x and y distances
def dist_between_points_taxicab(point1, point2):
    return (abs(point1[0]-point2[0]) + abs(point1[1]-point2[1]))

#randomly distributes num_stores points across a circular area of radius circle_radius
def generate_points(num_stores, circle_radius):
    stores = []

    for i in range(num_stores):
        points.append (generate_point(circle_radius))

    return points

#generates a random point in a circular area of radius circle_radius
def generate_point(circle_radius):

    #tuple, first entry is an angle from 0 to 2*pi, second entry is a distance from the center
        #the second entry scales random.random() to the half power.  This keeps it as a range from 0 to 1
        #while biasing towards higher numbers in a way that accounts for the fact that circumference
            #increases with radius,
            #i.e. if it was an equal distribution, more points would be crowded around the center
    new_point = (random.random()*2*3.14159265, sqrt(random.random())*circle_radius)

    #from polar to rectangular coordinates, then return
    return (new_point[1]*cos(new_point[0]), new_point[1]*sin(new_point[0]))
```

Figure 20.B: Grocery store distance simulation code, continued

```
#multiplied by 2 to include return trip in calculation

#e-vans:
print("e-van")
print(2*closest_dist_multiple(1944,60,10000))

#e-bikes:
print("e-bike")
print(2*closest_dist_multiple(144,5,10000))
```

```
e-van
3.07038517557152
e-bike
0.952260512586957
```

Figure 21: Grocery store distance simulation code results