**Supportive Information**

**Appendix A: Complete Case study analysis**

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| **Splosh**  |
| **Four Lenses Framework** | **Current System**  | **Barriers**  | **Opportunities**  |
| **Supporting Systems** | - Raw materials come from **outside of the UK**, but bottles and packaging are produced in the UK. The production and formulation of the sachets and final packaging for delivery happens in the **Splosh factory**. - Distribution of orders is made by using the **postal services**, and orders are just delivered inside the UK. | - Heavily dependent on the postal services, which **could increase costs** in a long term.- Existing on-line and of-line retailers offering Splosh products could **disrupt the reuse and return** of their plastic bottles.  | - Opportunities to use digital intelligence to **build their own distribution system** with capabilities of taking back the bottles to be reused by other users.  |
| **Systems Enablers**  | - Use of an **online platform** (website and mobile app) to capture orders from users. - They sell to **third parties** to resell their products. - **Use of database** to remind users about ordering new sachets.- Use of **social media** to promote and communicate with users. | - Different sale channels could **disrupt a system integration** that can allow further capabilities to take back the bottles to be reused by other users.  | - **System integration** to have a single system that captures **online orders** from different products. E.g. Amazon Dash[[1]](#footnote-1). |
| **Design** | - The cleaning liquid is made of **biodegradable high quality ingredients, which** do not harm the environment at the end of life.- Cleaning liquid range for products for home cleaning, laundry, dishwashing and hand and body.- The bottles are refillable and can be **reused** as many times as possible. Splosh says if the bottle is reused 20 times, it could mean 95% less packaging waste sent to landfill. The bottles are made of 30% **recyclable** plastic mainly from high-density polyethylene (HDPE), which can easily enter the recycling cycle. - The main **product innovation** compared to other cleaning products, is the distribution of sachets instead of filled detergent bottles. As products do not contain water and users can keep their refillable bottles, **Co2 emissions** of transport could be greatly **reduced**.- The delivery packaging of sachets is **letterbox size** so it can fit in the **mailbox**. The first order includes 2/6/8 bottles.  | - Continue to use single use plastic that can encourage users to reuse their bottles up to certain time **without a return option for a replacement** after certain period of time | -Improve the design of the bottles and have a **tracking and take-back system** in which bottles could be reused and reused by different users. This is in case the user would like to give their bottle back. |
| **Business Model** | -The business model consists of selling sachets of concentrated cleaning product through online orders. The user will ask minimum of two bottles in its first order and refill them. Sachets will be **ordered** every time the product is over.- The business model follows **environmental sustainability** principles as it is based on the assumption of cutting plastic waste. - A refill box with 4 sachets costs between £3.95 to £5.95 depending on the cleaning product. -The **relationship with the customer** (through an online platform and app) opens up a direct marketing channel, an extremely valuable way of communicating with users.- Orders are made **online** through their website. Users need a **subscription** to do an order.  | - If scaling up their business model, they might **jeopardize the close relationship and trust** they have with their current customers. - **Environmental sustainability principles** could be jeopardized if not all bottles are re-used as thought.  | - Use data captured through orders to give **personalized promotions** and reminders of when to order products.- Opportunities to set up **micro-franchises of factories** in other parts of Europe to expand their market. Use of autonomous robotics, cloud computing and big data analytics to monitor, control and optimize operations, keeping a strong relationship with customers.- Opportunities to **explore further circular options** to their packaging that involve take back schemes.  |

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| **Graze**  |
| **Four Lenses Framework** | **Current System**  | **Barriers** | **Opportunities**  |
| **Supporting Systems** | - Ingredients are sourced **locally** but also from **all over the world**. They use 250 ingredients across 106 products. - Snacks are produced and packaged in the **Graze factory**. Most of the work is done by **robots,** but some snacks required manual work by humans. - Distribution of orders is made by using the **postal services**, and orders are just delivered inside the UK.- They **own their supply chain**. They are the procurers, buyers, manufacturers, pickers, packers, fillers, and distributors. | - Heavily dependent on the postal services, which **could increase costs** in a long term.- If to scale up to sell in major retailers and not on-line, their distribution system would **not consider** meeting **regional sourcing matched to consumer demand and preferences.**  | - More **local regional sourcing:** Match customer preferences to locally source ingredients for snacks.- Work with suppliers according to **demand** - Opportunities to use digital intelligence to **build their own distribution system** with capabilities of taking back the boxes and other packaging to be reused by other users.  |
| **Systems Enablers**  | - Use of an **online platform** (website and mobile app) to capture orders from users.- **Use of algorithm** to capture preferences of users. E.g. Type of snacks, dietary requirements, when to ship a box, type of box, where to deliver the box, etc. - **Use of algorithm** to records the customer's order history and preferences, monitors stock levels and tracks the location of workers on the factory floor- Use of **social media** to promote and communicate with users. | - **Security of their data** could be jeopardize if they do not implement new technologies such as block chain.  | - Opportunities to further **connect individuals to local producers.** Users will know where their snacks come from. - Better target **customer and supply chain needs.**  |
| **Design** | - **Snacks reinvented** - Production of high **quality and healthy** snacks.- **Users can select their likes and dislikes and dietary requirements** from the website. This will be captured by **DARWIN** to select from **4.9 million different combinations** of snacks to put in the customer’s box. Every time a customer orders a box will be different to keep a ‘surprise element.’  - Graze has up to 1**7 different type of boxes** the user could choose from. Boxes contain between four and five snacks that have **exact portion sizes** to give the best nutritious value. The boxes are made of recycled cardboard and are **letterbox size** so it can fit in the **mailbox**. Other packaging material also have **recycled content** and come from **sustainable sources.**  | Continue to use single use packaging that can encourage users to throw it away **without considering a recycling/composting option**.  | - Use data captured through orders to give **further customization**. Be able to choose exactly the snacks without too much of the ‘surprise element’- Opportunities to improve the design of the packaging and have a **tracking and take-back system** in which the boxes, the punnets and the skewers could be reused and reused by different users.  |
| **Business Model** | - The business model consists on selling boxes of **personalized** **healthy snacks** through posting the box to the end customer. - The business model follows **environmental sustainability principles** towards sourcing their ingredients and packaging, as well as **social sustainability principle** towards providing a healthy option. - There market size is of 100,000 customers in the UK, which order boxes mainly for the office and also for parties at home.- Orders are made **online** through their website. Users need a **subscription** to do an order. Order could be placed weekly or fortnightly.- They recently started **operating in the US** with a replication of their business model in the UK. | **-** If scaling up their business model to sell in major retailers, they might **jeopardize the personalization element** that distinguish their business model. - **Environmental sustainability principles** could be jeopardized their packaging is not recycled or composted as supposed to be.  | **- Diversification in the market**: Schools, airplane snacks, etc.- Use data captured through orders to give **personalized promotions.** -Opportunities to set up other **micro-factories as franchises** in other parts of the world to expand their market. - Opportunities to **explore further circular options** to their packaging that involve take back schemes. |

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| **Unto This Last** |
| **Four Lenses Framework** | **Current System**  | **Barriers**  | **Opportunities**  |
| **Supporting Systems** | - Most of their furniture is made of birch plywood, which is **FSC certified**, and comes from Europe. - Other woods and laminates are sourced from Europe and America.- They have a focus on **micro factory**. The use of CNC technologies and made to order mentality, allows them **not to have overproduction, warehouse and packaging costs**. - They have a **LEAN manufacture mentality** where they look always to **improve**. - They offer home delivery with their **own delivery services** that used **electric vans**. They deliver just within London.- The delivery of items can be **flat packed**. Also they **delivered fully assembled**  | - Heavily reliable in their supply chain. If there is delayed on getting the wood, further **delays** could happen as they work according to demand.  | - Work with suppliers according to **demand.**- As they expand through micro-factories, they could use big data analytics to **optimize the delivery** of raw materials and finished productsacross regions.  |
| **Systems Enablers** | - Use of **CNC technology** to **optimize** the production systems. They **developed biometric software** that **allows adjustment** with regards to variations of wood and client needs. - **Utilize big data analytics** to **streamline supply chain management and scheduling**.- All production processes and products are **visible from the workshop.** | - **Security of their data** could be jeopardize if they do not implement new technologies such as block chain. | - Opportunities to further **connect individuals to the production process of their furniture.** Users could get involved in the design and production through a learning platform that Unto This Last could provide. This could enhance **product attachment** and thus **longevity**.  |
| **Design** | - Furniture is designed to be of **high quality** and ‘**made to order’** by **local craftsmen** in a workshop in East London which also serves as their retail space. - The design of their working environment is **designed with care** as their products. - They **optimize** use of materials by using **CNC technologies** without wasting any material. - They use a range of different materials and **allow input from the client** to choose a variety of choices for tailored finishes. - They offer **specific designs** with **specific dimensions**. But their software allows to **adjust the designs to the dimensions required** by the customer. - **No packaging** - the furniture is delivered wrapped in blankets  | - **Few designs** to offer to their customers.- Not thinking about **assembly and disassembly features / modular design**  | - Generate a **community of designers** that can propose new designs to be produced in these micro-factories. Made.com and Open Desk implement similar open-design strategies.- **Re-think the assembly features** of all products so they can be delivered flat packed and do the final assembly at the customer’s home.  |
| **Business Model** | - Their business model is based on transactional sales of **‘made to order’** furniture in a **small-scale process**.- The business model follows **environmental sustainability principles** towards avoiding over-production, as well as **social sustainability principle** towards providing a community sense with their customers. - Focus on customer. Meet customer expectations by being **small, friendly, and efficient.**- They **sell a story** rather than a product. - They consider to be an enterprise with **tangible/transparent integrity**. - Their price strategy is based on providing **high quality** goods at **mass-production prices**. - Thinking on **franchising** their process.  | **-** If scaling up their business model, they might **jeopardize the personalization and community element** that distinguish their business model.- **Environmental sustainability principles** could be jeopardized if their furniture is disposed before it should be and does not go to remanufacture or a second hand market.  | - Opportunities already identified by the company to set up **micro-franchises of factories** in other parts of UK and Europe to expand their market. Use of digital intelligence to monitor, control and **optimize operations.** - Opportunities to **explore further circular options** to their furniture including re-manufacturing.  |

**Appendix B – Discrete Event Simulation (DES) model descriptions**

**Splosh**

The discrete event simulation (DES) model for the Splosh business is shown in the Figure above. The model includes:

* the supply of cardboard packaging, shown in the elements with names CB,
* the supply of bottles (and trays), manufactured from polymer, element names Bot\_tray and Det\_bottle,
* supply of detergent sachet, element names Det\_sach,
* supply of film packaging, elements with names Film

The centre of the model is the Splosh\_package element which takes cardboard, bottles\_trays and film and combines them into a shipment to a Customer. The supply of detergent sachets is shown as a separate supply line allowing the model to represent both conventional detergent supply and the Splosh business model of only supplying detergent in sachets. Customers then sort the delivered shipment – cardboard is recycled back to the cardboard supplier, film is discarded to landfill, and the bottle\_tray is combined with the detergent sachet to provide detergent. The customer then uses the detergent for a 7 week period, represented by the Cust\_use element, at which point a decision occurs when the bottle is “Empty”. The bottle entity enters the “Bot\_tray\_choice” element and a proportion is sent on either route, dependent on the scenario being modelled. The standard model sees all bottles recycled, so the choice is for 100% of bottles to enter the recycling route - labelled as “Recycle (conventional) option for bottles”. The Splosh models, labelled as, “Re-use (Splosh) option for bottles” have use periods of either 1 year or 3 years for the bottle and hence probabilities are assigned for the bottle remaining in use, or sent for recycling. In a 1 year re-use scenario the probability for recycling is 7/52 (13.5%) derived from the 7 week use period and 52 weeks in a year. For the 3 year re-use period the probability of recycling is less at 7/156 (4.5%) - 7 week use period divided by only replacing after 3 years (52 x 3).

On the re-use route for Splosh the bottle is directed to the entry point of Bot\_tray\_use and is combined with a new detergent sachet to then enter the next 7 week Cust-use step. On the conventional re-cycling route the bottle is direct back to the supplier of bottles and is recycled. It should be noted that both cardboard suppliers and bottles\_tray suppliers have customers other than Splosh, represented as the alt-customers elements.

The model is run for a 10 year (520 week) period, to determine how many bottles are required. Three different scenarios were investigated:

* Standard (conventional), with detergent supplied in a bottle every time more detergent is required (approximately every 7 weeks),
* Splosh, detergent in sachets, with a replacement bottle needed after approx. one year of use,
* Splosh, detergent in sachets, with a replacement bottle needed after approx. three years of use.

Data is collected on the numbers of bottles (entities in the DES model) that are used, re-used and recycled, by recording the numbers of entities that pass through the relevant nodes in the DES model.

**Graze**

The DES model of the Graze supply chain is shown in the figure above. It is assumed that each Graze box consists of one cardboard box, four PET polymer trays (punnets), four film lids, three bamboo skewers and food content. The recycled materials of cardboard and Polymer PET are already part of a circular material flow. New feedback loops are proposed to enable packaging reuse by Graze, with recycling where reuse is not possible. The model was run to simulate Graze delivering 300,000 boxes of food per year, based on company reports of business volumes in the UK.

The key parts of the DES model are:

1. Assembling 5 items to ship – food, skewer, PET tray, film lid, cardboard box
2. The cardboard supply and existing recycling option for end-of-life (EoL)
3. The PET polymer supply and existing recycling option for end-of-life (EoL)
4. Use of the food and disassembly of packaging with EoL options – percentage choices for recycle or disposal for some materials
5. The new option of materials take-back by Graze, rather than use of recycled material from their suppliers.

The re-use options by Graze are modelled by giving the customer a decision point after the “customerUse” element, with percentages of the packaging materials directed either to the conventional route or the Graze take-back route. Once materials arrive back at the “grazeDismant” element of the model they are assigned to the 5 elements of: food, cardboard (CB), polymer (PET), film or skewers. Food and film have no re-use possibilities and are sent to landfill. Cardboard, PET and skewers are inspected for possible re-use, and dependent on scenario, are re-used in varying percentages or sent to landfill in the case of skewers or for recycling with cardboard and PET. Inspection of the connection points in the diagram above shows these flow routes for these material use options.

Data is collected on the numbers of different material components (entities in the DES model) for cardboard boxes, polymer (PET trays, film lids, skewers and food items, by recording the numbers of entities that pass through the relevant nodes in the DES model.

**Unto-This-Last**

The DES model of Unto-This-Last’s (UTL) manufacture and supply of a trestle table is shown in the figure above. The rate at which tables arrive with customers is set by the supply of plywood sheets that are used to manufacture the tops, legs and cross-pieces for the table, and this supply is set at two per month, which is the rate at which Unto-This-Last can manufacture new tables. The 3 elements of tops, legs and crosspieces are combined into a delivery for a customer, who uses the table for a period of time set by the use period in the “customer” DES model element. At the end of the use period, customers have a choice and probabilities for the options are set in the “Use-end” model element. The options are to either send the table back to UTL for remanufacture; to sell it to a 2nd customer, or to dispose of the table.

In the remanufacturing loop, tables are sent to the “UTL\_reman” element and separated into the 3 components (tops, legs, cross pieces), using the “xpc\_chk” and “top\_legs\_chk” elements to create the individual components in the correct ratios. Each component is then has probabilities assigned for either disposal, or for re-manufacturing and further use. Re-manufactured components can then re-enter the use phase through the “tops”, “legs” and “x\_piece” model elements. The model records how many tables, and table components are in use through time, and how many are supplied to customers, by recording the numbers of entities that pass through the relevant nodes of each element.

The DES model examines the effects of customer choices over length of time used and the options once the customer decides to not use the table. The options explored are:

* Customers send tables to disposal
* customers choose to re-sell tables to a second customer
* Customers return the table to UTL for re-manufacture
* The length of time the tables are used is varied from 10 to 5 to 2 years.
1. https://www.amazon.com/b/?node=10667898011&sort=date-desc-rank&lo=digital-text [↑](#footnote-ref-1)