STUDY 2

One Man's Trash is Another Man's Treasure
Operational Agility in the Circular Economy

4499 Research Project
Ivey School of Business
Shania Fernandez
Professor Jury Gualandris
April 2020

Abstract

Many firms in the agri-food industry are recognizing the negative environmental and economic effects caused by the traditional linear food system. Shifting to a circular economy model allows these firms to use external waste streams as inputs for their products. Although this is a positive solution to excess food waste, the use of another firm's waste adds an element of variety (complexity) that a firm must be able to absorb.

The goal of this project is to elaborate on existing theories of operational agility in the context of waste exchanges. Specifically, this project builds on Ashby's *Law of Requisite Variety* to develop a framework for understanding operational agility depending on a firm's ability to manage external variety through their existing levers of internal variety. Through four case studies of firms in the agri-food industry that are exploring and implementing potential waste synergies, this project assesses similarities and differences in their sources of external and internal variety and their achieved level of waste exchange proficiency.

Table of Contents

1. Introduction

As firms in the agri-food space explore strategies to integrate sustainability into their core operations, many are looking into shifting their supply chains from the traditional linear model of food production to a more circular alternative. The circular economy connects firms so that the by-products of one organization becomes the inputs for another's products. However, implementing the circular economy model remains challenging, as the buying firm faces high operational variability due to the nature of waste.

The *Centre for Technology Transfer in Industrial Ecology (CTTEI)* has identified potential waste synergies between firms located in Québec. The objective of this paper is to identify similarities and differences among four small to medium-sized firms that have agreed to explore these waste synergies. Specifically, this report will examine the operational agility of each firm in response to the different sources of external and internal variability they face.

2. Literature Review

Introduction to the Circular Economy

A circular economy entails "gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system".[1] It exemplifies a stark contrast to the traditional way of business and manufacturing. During the industrial revolution, the invention of the steam engine provided humans with the ability to develop new products at a rapid rate, with a misconception that they had infinite resources for these innovations.[2] Since then, firms and societies have continued to increase this pace of innovation with the same mindset of unlimited resources. This has created a linear economy in which resources are taken from the earth, used, and then discarded.

Fortunately, there are opportunities for pioneers to disrupt this "take-make-waste" system by addressing three principles to develop a circular economy.[3] First, they must change their mindset to "view waste as a design flaw" and to ensure that waste and pollution are designed out in the first place. Second, circular economies require products and materials to be reused, repaired, and remanufactured so they can provide value for longer periods. Finally, circular economies involve the regeneration of natural systems by returning valuable nutrients back to their original ecosystems.

Ultimately, waste does not exist in circular economies. Instead, products are optimized for reuse, and synergies are formed between participating players to create an infinite life cycle of the components within the product.
The research outlined in this paper will explore how food-production companies can contribute to the development of a circular economy. By determining the operational practices that allow firms to extract and capture value from their waste, firms can address the principles of designing waste out of their production, as well as keeping products and materials in use.

Circular Economies in the Food Industry

[1] Ellen MacArthur Foundation. (2017) *Concept. What is a Circular Economy?* Retrieved from https://www.ellenmacarthurfoundation.org/circular-economy/concept
[2] Ibid.
[3] Ibid.

Within the agri-food industry, there is an opportunity to deviate from the traditional linear food system. Although the current system has benefited cities by fuelling urbanisation, economic development, and supporting fast-growing populations, it also has had substantial negative environmental and economic impacts.[4] The aggressive agricultural practices in place today are responsible for over 39 million hectares of degraded soil and places demand on approximately 70% of global freshwater.[5] According to the Food and Agriculture Organization of the United Nations, approximately 1/3rd of the food produced for human consumption gets lost or wasted. This equates to roughly $680 billion USD in industrialized countries and $310 billion USD in developing countries.[6]

Shifting to a circular economy aims to address these costs through three goals:

1. Sourcing food grown regeneratively and locally,
2. Designing and marketing healthier food products, and
3. Making the most of food.

Operational Agility

Operational agility is the ability of firms' business processes to exploit emerging opportunities for innovation in a manner that is quick and effective compared to their competitors. Operational agility can be divided into four types:[7]

1. Product agility is the ability to meet sudden demand for a product that is different than what the firm is currently making. This is focused on managing variability caused by changing customer demands.
2. Input agility is the ability to quickly produce a good or service with consistent quality despite having a different set of inputs.
3. Process agility involves finding alternative ways to continue operations when a crisis emerges.
4. Scale agility is the ability to adjust to variations in market demand. It requires identifying methods to achieve the scaling up or down of production.

This report will focus primarily on input agility, and a firm's internal ability to meet customer demands while managing the variety and variability of their inputs in a circular economy.

Operational Agility and Circular Economies

Operational agility is a critical component of developing circular economies. Many firms entering the circular economy have pre-established businesses that operate as part of a linear economy. However, they are looking for opportunities to expand their operations to use external waste streams. The use of another firm's by-products poses the challenge of managing variety and variability of inputs. By relying

[4] Ellen MacArthur Foundation. (2017) *Food and the Circular Economy.* Retrieved from https://www.ellenmacarthurfoundation.org/explore/food-cities-the-circular-economy
[5] Ibid.
[6] UN Environment. (n.d.) *Worldwide Food Waste*. Retrieved from: https://www.unenvironment.org/thinkeatsave/get-informed/worldwide-food-waste
[7] Prasad, B. (2018). *Nimble : make yourself and your company resilient in the age of constant change.* (Revised edition). New York, New York: TarcherPerigee.

on another firm's varying waste as their input, firms must coordinate material flows and ensure that they can still meet, or find, customer demand.

In a circular economy, there are at least two roles involved in creating a waste synergy between firms. First, there are firms who turn their waste into a product that can be recycled back into their own supply chain or sold to other firms. Although these firms face the challenge of managing the distribution of their by-products in addition to their primary products, they have full control of these processes. Second, there are firms that purchase and use these by-products.

Waste exchanges are unique when compared to traditional supply markets because they typically involve lower volumes, and buying firms "operate under high uncertainty with regard to the nature of the products, the structure of their negotiations with suppliers, and potential competition with other buyers".[8] Furthermore, waste exchanges are a surplus-driven supply network (SDSN). Where a traditional supply network matches supply with demand, SDSN's put the responsibility on the buyers to adapt to the variability of suppliers' waste.

Ashby's *Law of Requisite Variety* states that "only variety can regulate variety"[9]. It is because of this requisite variety that "organizations have to be preoccupied with keeping sufficient diversity inside the organization to sense accurately [and respond efficiently to] the variety present in ecological changes around it".[10] This paper will explore how firms can use internal variety to manage the external variety that is inherent in waste synergies.

3. Methodology

This project involves a combination of primary and secondary research. Primary research will be conducted via phone or video interviews with four firms that have identified potential synergies to integrate circularity into their operations, as well as the facilitators of these synergies. Secondary research will be completed through online databases and research papers.

This project uses the abductive theory elaboration approach, using case studies to elaborate and refine existing theories on operational agility. First, the study involves a literature review of existing theories on the circular economy, the agri-food sector, and organizational agility. Then, the project will contextualize these theories through the four case studies. Through this simultaneous approach of analyzing general theory and empirical context, this project aims to identify and elaborate on the relationships between internal variety and external variety in a waste exchange context.[11]

---

[8] Dhanorkar S., Kim Y., and Linderman K. An empirical investigation of transaction dynamics in online surplus networks: A complex adaptive system perspective. *J Oper Manag. 2019;65:160–189*. Retrieved from https://doi.org/10.1002/joom.1006

[9] Ashby, W., & Goldstein, J. (2011). Variety, Constraint, And The Law Of Requisite Variety. *Emergence : Complexity and Organization*, *13*(1/2), 190–207. Retrieved from http://search.proquest.com/docview/1349787972/

[10] Menor, L., Roth, A., and Mason (2001). Agility in retail banking: A numerical taxonomy of strategic service groups. *Manufacturing & Service Operations Management* 3, (4) (Fall): 273-292, http://search.proquest.com.proxy1.lib.uwo.ca/docview/200660621?accountid=15115

[11] Ketokivi, M., & Choi, T. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management*, *32*(5), 232–240. https://doi.org/10.1016/j.jom.2014.03.004

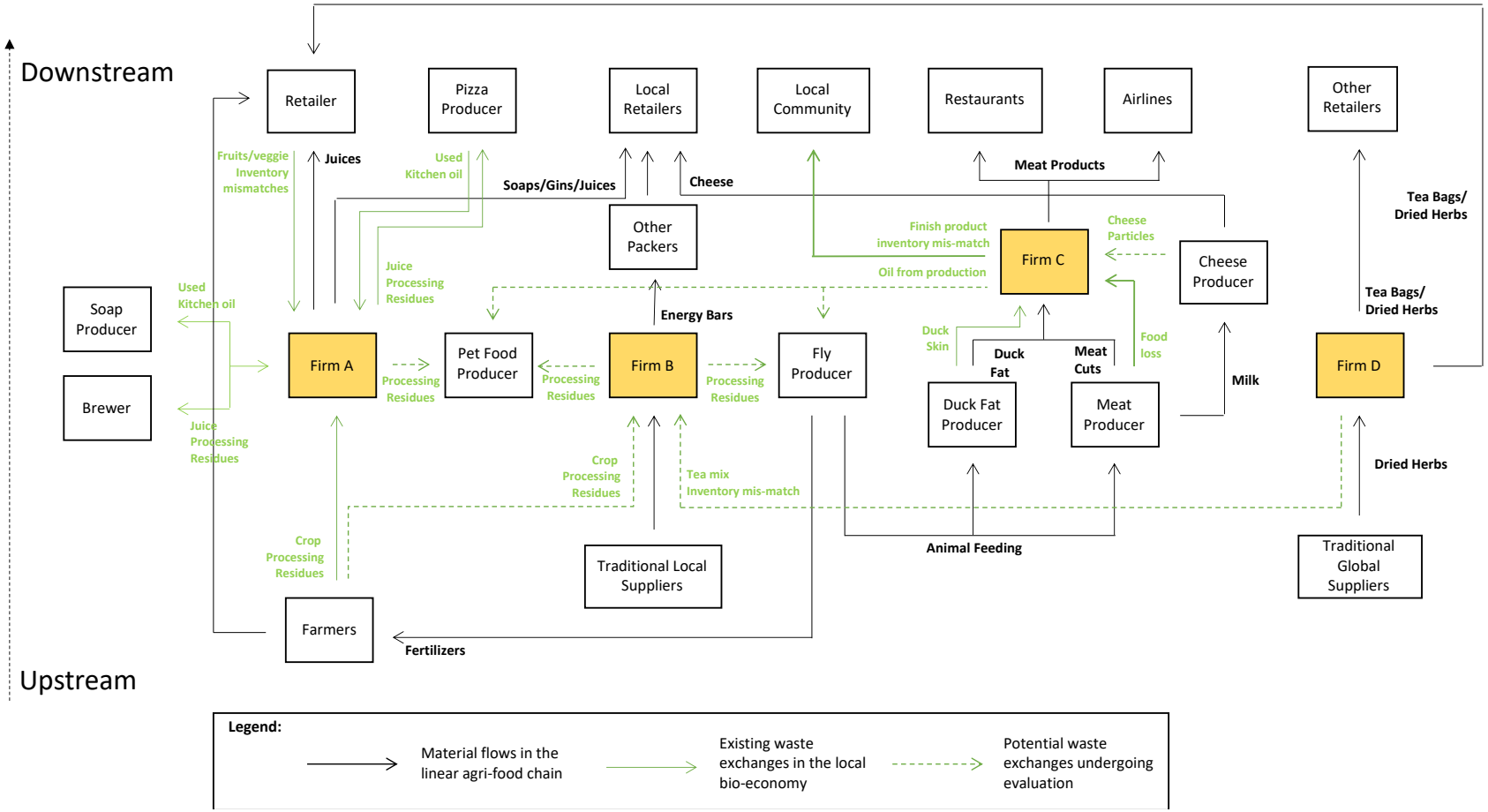
Table 1 – List of case studies and interviews

Case	Location	Number of Employees	Products	Waste Exchange Proficiency	Interviewees
Firm A	Montreal, Quebec	25	Food recovery and transformation (juices, soaps, alcohol)	High: Currently producing fruit juices, alcohol, and soaps made out of wasted produce, potato peels, and fat. Recycled products account for 100% of its product portfolio. Now expanding via local "replication" in California.	Founder, Company Partner (Retailer and Supplier), Circularity broker (PME Montreal)
Firm B	Chateauguay, Quebec	70	Private label nutrition bars	Medium: Currently evaluating the adoption of flour, produce, and dairy in various bars.	Vice President of Business Development, Circularity broker (CRE Montérégie)
Firm C	Saint-Hyacinthe, Quebec/ Palencia, Spain	100	Prepared meat dishes	Medium-High: Duck fat, meat trimmings are currently sourced and used into 5-10% of the product offerings. The firm is assessing a new waste exchange involving cheese particles.	Director of Operations, Circularity broker (CRE Montérégie)
Firm D	St-Bruno, Quebec	135	Tea bags	Medium-Low: feel motivated but still gathering information and resources. Stuck in the discovery phase for now. Considering selling its waste to beer producers and sourcing produce (such as fruit pulp) to produce tea.	Project Coordinator, General Manager, Circularity broker (CRE Montérégie).

Network Map of Case Studies

This figure displays the relationships between the firms and facilitators included in this report.

Figure 1: Network Map[12]



Note: This emergent network could potentially be more resilient to short-term supply and demand shocks because each actor diversifies their input and output sources, resulting in higher interconnection but lower interdependency in the regional system.

[12] Firm Interviews.

Case Studies – Single Case Synthesis

Firm A

Firm A is a Montreal-based start-up specializing in food recovery and transformation. Founded in 2016 by a serial entrepreneur coming from the restaurant industry and his partner who specialized in sustainability, this firm aims to find a solution to excessive food waste in Canada.

Four years ago, the partners were contacted by the operations manager of a major distributor of fruit and vegetables in Montreal. Witnessing the amount of excess food waste his own factory was producing, the operations manager presented an opportunity to find alternative uses for their excess fruits and vegetables and joined Firm A on their mission. Together, the three partners began to produce and distribute cold-pressed juices.

Since then, they have grown to have over 25 employees and have expanded their product offering to include over twenty different juices, spirits, and soaps, all made with food waste.[13] All products are made in-house and are sold to retailers, restaurants, and supermarkets across North America and Europe.

Firm A is an outlier compared to the other firms in this report because they are a start-up, not an established firm. However, their founders have previous experience working in established firms. This sets them apart from the other case studies as the firm was formed to challenge food waste, as opposed to the other firms which recognized an opportunity to be more circular after multiple years of operation.

Firm B

Firm B is a private-label bar manufacturer and co-packer founded in 2001. Originally operating as a manufacturer of marshmallow squares, they diversified their products by offering customized bars and focusing on manufacturing allergen-free, nut-free, and kosher-certified products. Today, they have over 70 employees and offer a wide range of bars, ranging from fruit bars to energy bars.

Based on their core values of flexibility and innovation, they have invested in research and development interns who analyze market trends in the agri-food space. This research has led them to explore opportunities to integrate circular solutions into their business.

Previously, they faced challenges with an inability to manipulate the waste into ingredients that were suitable for their bars. However, in the past year, Firm B has completed the construction of a new facility in Chateauguay, Quebec, allowing them to double their production capacity and invest in machinery that will allow them to modify ingredients for future products.[14]

Although Firm B has not currently integrated any waste streams as inputs into their products, they have previously given their waste to an animal food producer. With the move to their new factory, they have not been able to continue this relationship due to the distance.

[13] Retrieved from company website.
[14] Retrieved from company website.

Firm C

Firm C was founded by two Spanish entrepreneurs who wanted to provide high-end, semi-processed meat products to hotels, restaurants, and other institutions. Firm C operates in Saint-Hyacinthe, Québec and attributes their success to their 50+ employees. Their products are cooked sous-vide and are required to follow many food safety regulations.

Firm C is built around strong relationships with their customers and places a high priority on building connections with local businesses. Because of these relationships, their food scientists are able to adjust recipes to meet customer demands and also incorporate new ingredients. There are two ways in which they develop products: customers may request specific dishes, or the food scientists develop new recipes and present it to potential customers.

Although initially interested in selling their waste as an additional stream of income, they realized that there were not enough viable customers *and* that they did not produce large enough quantities. However, they have had success in purchasing other firms' waste and using them as ingredients for their products. For example, they have purchased meat trimmings from another firm and have created a line of meatballs developed by their food scientists. More recently, Firm C has assessed another opportunity from an existing supplier of duck legs, where they are looking at potentially purchasing by-products from their duck fat melting process.

Firm D

Founded in 1992, Firm D specializes in processing herbs and spices to create teas. Serving countries across North America, Europe, and Asia, Firm D is recognized as a leader in the development and packaging of herbal teas. Currently, they sell their products under four private-label and home brands through a variety of distributors, including retailers, wholesalers, hotels, and restaurants.[15] Every day, their facility manufactures and packages approximately 10 million tea bags. The majority of their dry ingredient suppliers can be found overseas, as the raw materials required do not naturally grow in Canada.

Firm D is driven to become more sustainable through their operating processes and ingredients as "it is the right thing to do".[16] Previously, they pioneered the offering of fair trade and organic products in Canada showing an existing commitment to sustainability. Moving forward, they are looking for opportunities to sell their waste to other firms or purchase waste streams.

[15] Retrieved from company website.
[16] Firm Interviews.

4. Analysis of Firms' Operational Agility

The purpose of this section is to compare the various external and internal sources of variability between the four firms studied, as well as how they are responding to each of these sources of variation. **Note** that external sources of variety relate to both the 'regular' task environment[17] but also to the characteristics of a specific waste synergy being considered or adopted. This content comes from firm interviews.

Table 1: External and Internal Sources of Variability and Firm Responses

	Firm A	Firm B	Firm C	Firm D
External Sources of Variety and Variability in the Task Environment				
Market Characteristics	Firm A's end customers are environmentally-conscious. The firm offers a rotating product selection year-round, meaning that customers are unable to purchase their favourite flavours at certain periods. However, customers are still willing to purchase from the firm because they support their mission of waste reduction.	Firm B creates private-label bars, meaning their products are dependent on the customization requests of their clients. This limits the possibility of their waste exchanges as they have varying quantities and ingredients required.	Firm C sells private-label products for clients, as well as their own branded products through retailers. By serving restaurants, they must develop recipes according to client specifications. However, these requests are rarely for specific meals. Instead, they are focused on dietary restrictions or nutritional value. In their own brand, they have more creativity to develop recipes based on the raw ingredients available to them.	Similar to previous firms, Firm D creates both private-label products in addition to their own brand. The majority of the products they produce are for larger clients who request specific blends and/or product benefits.
Supply Characteristics	Firm A purchases fruits and vegetables from their suppliers, meaning they are	Firm B has had difficulties finding suppliers with a constant stream of by-	Firm C is purchasing by-products from the meat industry, which has little	Firm D strictly uses fair-trade ingredients, which limits the

[17] Scott & Davis (2007) succinctly summarize the difference between environment and task environment: "*Environment* is the more inclusive term and incorporates technological, political, and institutional aspects of the organizational context. *Task environment* emphasizes those features of the environment relevant to its supply of inputs and its disposition of outputs but also includes the power-dependence relations within which the organization conducts its exchanges." (p. 125).

	subject to seasonality with their ingredients. Because of Firm A's early success, they are often contacted by firms looking to sell their waste. This gives the firm a broad supplier base to select from to diversify risk and hedge variabilities from individual supply sources. This established network of suppliers also uses their spare capacity to serve the new soaps and alcohols that Firm A has introduced.	products to meet their current activity level.	seasonality. Therefore, they have a consistent stream of waste throughout the year. Additionally, the suppliers of their by-products are their current suppliers, meaning they have established relationships.	potential suppliers they can purchase from. Their ingredients must be completely dry. However, the majority of available organic waste is wet, requiring an additional dehydration process that Firm D does not currently have the processes for.
Globalization	Close proximity to main customers and suppliers, facilitate information and knowledge sharing.	Localization is key for Firm B. Although they had previously sold their waste to animal feed manufacturers, they recently moved their factory to a rural area and no longer have this capability. There is a tradeoff companies have to be willing to make if the transport costs are too great compared to the volume they will receive.	Firm C is focused on localization. Both their customers and suppliers are within close proximity of their manufacturing facility. One of their waste exchange partners is located within 50km away. Therefore, if there is variability in their supply, they are able to easily travel and make arrangements to find the difference.	Firm D's suppliers are international. They stated that when they receive wrong orders, it is recommended that they waste those ingredients as it is cheaper than sending them back to the suppliers.

Note: while the sources of variety and variability listed in the first section of the table are external to the boundaries of the firm, they are influenced by how the firm has been set up. For example, the firm has some control over the market they choose to target as well as the location of their facilities and their suppliers. Therefore, they have some indirect control over their market characteristics and globalization

	Firm A	Firm B	Firm C	Firm D
Internal Sources of Variety and Variability within Firm Boundaries				
Product Development Process	Firm A changes their product offering based on what produce is available in that time period. Because their end-products are juices and soaps, the physical appearance of the inputs is irrelevant.	Firm B's broad product offering allows them to be agile, as long as their customers request bars that have the available waste streams as ingredients in their bars.	With a wide range of products, Firm C has the flexibility to develop new recipes and present them to customers.	Because Firm D produces dry foods, they are subject to many regulations with regards to their ingredients. This limits their ability to use another firm's waste streams. However, the endless possibilities of ingredients for tea production allows them to explore various suppliers.
Operating Processes	To mitigate seasonality, Firm A freezes their orders of produce to allow them to have a consistent "supply" of fruits throughout the year. This creates a buffer inventory by allowing them to buy in bulk when specific produce are available and spread it throughout a six-month period.	Currently, Firm B owns single-function equipment that allows them to "mash and mix" their inputs. Previously, they did not have the machinery or processes to modify any waste streams and allow it to be a viable ingredient in their bars.	Firm C uses one process for all their products. By using the sous-vide cooking method, they eliminate internal variability that is often present when firms must manipulate their inputs. Firm C has a flexible production schedule, as they change their production batch daily to comply with washing and sanitizing regulations. Their set-up costs them one hour of production and requires minimal machine adjustment.	All dry ingredients that Firm D receives must go through a sanitization process that eliminates any pests before going into storage. Furthermore, all dry ingredients are stored in separate rooms to avoid mixing of smells.
Employee Capabilities	Firm A's has a small team of approximately 25 employees. Their leadership includes three co-founders who have diverse experience in sustainability, entrepreneurial ventures in the food industry, and operations management. They have strong resource orchestration capabilities.	Firm B initially saw the opportunity for circularity through their research and development interns. Currently, they have one employee who dedicates 50% of his time to sourcing potential waste streams.	Firm C's greatest strength is their food scientists, who are able to see the volume and quality of potential waste streams, and develop recipes accordingly.	With approximately 150 employees, Firm D is the largest of the four firms analyzed. Currently, they have appointed one project manager to explore these opportunities.

Through the analysis of each firm's sources of external variety and variability, there are key similarities and differences that highlight how their varying levels of existing internal agility have helped or hindered them from pursuing the waste stream synergies. In situations where their existing operational agility is not sufficient to meet these external factors, they have had to rely on improvements to their internal variety to accommodate them.

Supply Characteristics vs. Operating Processes

Initially, the assumption was that all waste flows occurring between these firms would be highly variable with regards to the quality and quantity of by-products that suppliers could produce regularly. However, interviews revealed that this is not always the case. The *seasonality* of the core products of the suppliers is crucial to the consistency of by-product that they have the ability to produce.

For Firm A, they were concerned with the changing volumes of their supply, which consisted of fruits and vegetables. On the other hand, Firm C could rely on consistent waste levels from their suppliers because the duck by-products they are purchasing have a constant production rate throughout the year. Because this constant rate is an external factor, it removes pressure for the firm to improve their internal operational agility.

However, relying on seasonal products forces firms to develop internal processes that allow them to adjust production. In response to an inconsistent waste stream, Firm A has responded by freezing their fruit and vegetables, thereby extending their lifecycle. By leveraging this freezing method, they are able to buy by-products whenever they are available in bulk and spread them throughout a six-month period.

Firm A also leverages economies of scope rather than scale, which helps them to make the best out of any internal and external waste stream. For example, they expanded to soap and gin to be able to use excess supply of fruits and vegetables as well as their internal by-products (juices residues) and combine them with new upcoming external waste streams such as crop residues and used kitchen oil for frying chips. The have built and orchestrate a local network of partners that offer their spare capacity to create economies of scope.

Other firms have not been able to pursue these waste exchanges because they do not see the need to make changes in their internal operating processes. Firm D faces external variety challenges because their inputs must be completely dry while the majority of available organic waste is wet. To properly manipulate this waste stream, Firm D or their supplier must invest in machinery to dehydrate these ingredients. Otherwise, their process capabilities are not sufficient to integrate circular solutions into their products.

Supply Characteristics vs. Market Characteristics vs. Product Development Processes

Each of the four firms demonstrate an innate sense of innovation through their product offering. Juices, bars, meat products, and teas can all incorporate a variety of ingredients, giving these firms some form of internal agility. Additionally, the end-products of these firms do not require the inputs to be physically appealing, permitting them to use another firm's waste. However, there is a stark contrast between firms that create private-label products versus those that produce their own brand.

Firm B and D, which sell through private-label channels, develop products based on the specifications of clients. Therefore, they are following the traditional supply network of managing supply based on customer demand, according to Dhanorkar et al.[18] This poses a challenge when pursuing waste synergies as they must manage variability coming from quality and quantity of by-products from suppliers (if and when relevant), in addition to the existing variability they face from changing customer demands.

On the contrary, firms that have successfully used another firm's waste follow the SDSN model where they manage demand given supply. By adjusting their product offering based on the ingredients that are available to them, Firm A and C were able to use other firms' produce and meat by-products. To manage demand, they rely on their marketing and relationships with their customers.

Firm A's brand messaging is focused on their mission of repurposing waste in the food industry. By being transparent about their ingredients and production processes through their marketing, they are able to manage customer expectations. With a clear understanding of their mission, customers are more accepting of a seasonal, or inconsistent, product offering year-round

Firm C is able to adjust demand to new sources of "waste" supply by managing their customer relationships. Instead of designing products solely based on demand, Firm C looks for potential waste streams, gives their food scientists creative freedom to design recipes containing those by-products, and then *pitches* the ideas to customers. Because their customers are more concerned about nutritional value as opposed to specific recipes, Firm C has flexibility in their product development process.

In a nutshell, we observe the combination of a 'positive' source of external variety like having a growing, diversified portfolio of local customers with open expectations and a 'positive' source to internal variety related to product development to synergistically neutralize a 'negative' source of external variety that exists intrinsically in external waste streams.

Globalization vs. People capabilities

The circular economy is inherently local. According to the Ellen MacArthur Foundation, one of the potential solutions to the challenges within the traditional food industry is by growing and processing food locally, as it eliminates the negative environmental impact of transporting food.[19]

The company cases support this concept of local waste exchanges, as firms who are in close proximity to their suppliers have had more success in quickly integrating circular solutions to their operations. Firm A is unique as they selected their facility location because of its short distance (approximately 13km) from their initial and main supplier.

All of the cases interviewed through this report are small to medium-sized enterprises (SMEs), with the largest firm having 135 employees. While larger firms typically benefit from economies of scale and

[18] Dhanorkar S., Kim Y., Linderman K. An empirical investigation of transaction dynamics in online surplus networks: A complex adaptive system perspective. *J Oper Manag. 2019;65:160–189*. Retrieved from https://doi.org/10.1002/joom.1006

[19] Ellen MacArthur Foundation. (2017) *Food and the Circular Economy.* Retrieved from https://www.ellenmacarthurfoundation.org/explore/food-cities-the-circular-economy

bargaining power over their suppliers, SMEs do not have the same resources.[20] Instead of using their size to gain bargaining power over their suppliers, SMEs must rely on an empowered employee or team to oversee these waste exchanges and maintain strong relationships with suppliers.

One of Firm C's potential waste partners, who is also one of their existing meat suppliers, is located only 50km away from their facility. This close proximity, coupled with having a dedicated operations manager who frequently visits their suppliers, allows them to manage variability through clear communication lines. If they face any variability with the quality or quantity of the waste they purchased, they can easily commute to the supplier and collaborate to find solutions.

On the other hand, Firm D deals with international suppliers, adding multiple communication barriers. As opposed to the relationship Firm C is able to have with their suppliers, Firm D must manage different languages and cultures. Furthermore, Firm D cannot have face-to-face communication with their current suppliers unless they travel overseas. When looking for opportunities to buy waste, it is especially challenging for Firm D as their commitment to fair-trade sourcing limits their ability to partner with local firms. Therefore, they must invest in their people to develop these relationships with their existing suppliers *and* potential suppliers.

By moving their facility away from the area they already know, Firm B is missing out on potential opportunities offered by a densely connected and heterogeneous industrial sector. This can be seen in their loss of relationship with the animal food producer that is no longer able to use Firm B's waste due to their plant relocation and the longer distance.

The Law of Requisite Variety: extending our understanding of the role of agility in a circular economy

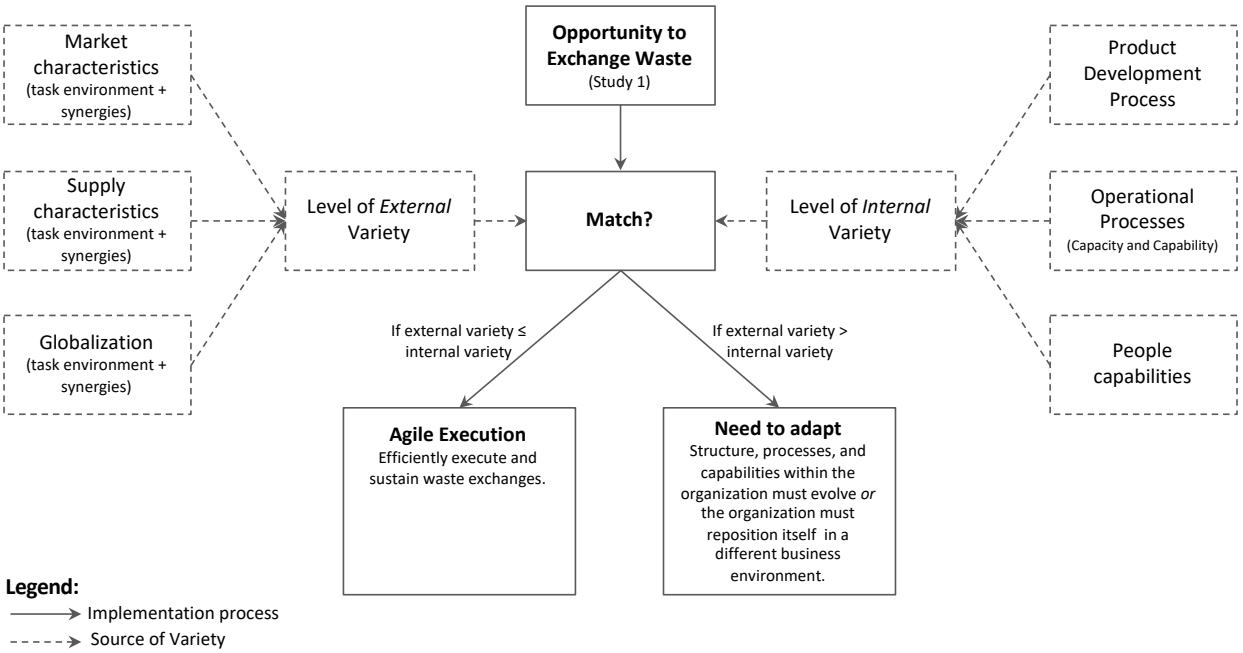
As previously discussed, the *Law of Requisite Variety* states that "only variety can regulate variety". [21] These case studies support this claim, as they demonstrate that a firm's operational agility, which depends on internal sources of "positive" variety, is essential in sensing and absorbing external variety posed by potential waste synergies, which add to the external variety that is normally present in a firm' supply chain and business environment. In cases where their internal variety is unable to balance their external, firms must recognize the need for and invest in changes to their internal capabilities to augment agility. This takes firms through a difficult adaptation process.

For agri-food companies assessing opportunities within the circular economy, they must first assess the external sources of variety stemming from market characteristics, supply characteristics, and globalization. After completing this assessment, they must then assess their internal variety and determine whether they have the existing capability to manage the external variability. If yes, they are able to pursue the waste synergies. Otherwise, they must respond by adapting their internal variety (Figure 2).

[20] Malekifar, S., Taghizadeh, S., Rahman, S., Khan, S. (2014). Organizational Culture, IT Competence, and Supply Chain Agility in Small and Medium-Size Enterprises. *Global Business and Organizational Excellence*, *33*(6), 69–75. https://doi.org/10.1002/joe.21574

[21] Ashby, W., & Goldstein, J. (2011). Variety, Constraint, And The Law Of Requisite Variety. *Emergence : Complexity and Organization*, *13*(1/2), 190–207. Retrieved from http://search.proquest.com/docview/1349787972/

Figure 2: A Framework for Understanding Operational Agility



Conclusion

Based on the literature review and case studies, there are several conclusions for the role of operational agility in the context of waste exchanges. Ultimately, operational agility for agri-food businesses in a circular economy can be defined as **having the existing internal variety required to manage external variety**.

External variety is determined by supply characteristics, market characteristics, and globalization. While these forms of external variety can counter-act each other (the negative variety of supply characteristics is mitigated by positive variety stemming from market characteristics in the case of Firm A), each of these sources can also be mitigated by internal variety (i.e., agility) in operating processes, product development and branding, and people, respectively.

Common sources of variety in **supply characteristics** are seasonality and the nature of the raw ingredients i.e., waste. To properly manage this source of external variety, the firm must have existing internal operational processes to extend the life-cycle of the waste and/or manipulate the ingredients to be a viable input, or even maintain a highly flexible manufacturing process that can seamlessly change batch sizes and product specifications at a relatively low cost for the organization. Having these processes in place indicates a high level of existing operational agility. Without these, firms must recognize the need to invest in and adapt their current operating processes or even try to directly tackle supply variety at the source.

Market characteristics revolve around customer requirements, differentiating between firms that create private-label products and firms (high variety) that sell through their own brands (low variety). To manage this source of negative variety, firms rely on their internal product development strategies. Moreover, because firms in the circular economy operate in a surplus-driven supply network where

supply is often 'given', they must also manage any market-related source of external variety through marketing strategies and client relationships, for example by building an environmentally-progressive customer base or asking customers to work with functional specifications rather than demanding for specific product configurations.

While **globalization** of buyers and suppliers is classified as a source of negative external variety and variability, proximity positively affects a firm's response to quality and quantity variability on both supply and demand sides. For example, close supplier proximity provides clear communication and solution development capabilities in instances of high waste variability (supply-side variety). We observe that firms operating in short supply chains necessitate of lower internal agility to achieve high levels of waste exchange proficiency.

Limitations

These findings are limited by multiple factors:

1. The number of firms that were interviewed. Four firms may not be representative of the entire industry. Furthermore, one of the firms (A) is an outlier as they are a sustainable start-up, compared to other firms who are transitioning to a more circular model. However, the analysis of this start-up is revealing of how external and internal sources of variety and variability co-determine the extent of waste exchange proficiency at an organizational level: the emergence of this organization has led to the creation of an internal and external levels of variety that match one another and allow to execute and sustain waste exchanges over time.
2. All firms included in this study agreed to explore waste synergies in the CTTEI project, indicating an existing level of agility.
3. This scope of this report does not quantify the operational agility of a firm. Further research and interviews can be conducted to assess each firm's internal variety as a continuous variable.
4. All firms are in the agri-food industry. To determine whether the framework of understanding operational agility is consistent throughout the circular economy, it can be compared to firms seeking circular solutions in other industries.