

**Towards a circular bio-economy:
“connecting the dots” to source and use food waste productively.**

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The Circular Economy (CE) connects firms so the waste of one organization becomes the feedstock for another (Geissdoerfer et al., 2017). The perpetual movement of material from one useful purpose to another in a circular fashion embodies the notion of sustainable development because business production and consumption are contained within the Earth’s planetary limits.

To achieve a circular economy requires eco-innovation and agility in sourcing and processing waste (Lombardi and Laybourn, 2012; De Angelis et al., 2018). Economic and environmental value can then be co-created via flowing waste where a higher order value application exists or can be created (Guide et al., 2003; Hopkinson et al., 2018). This can avoid waste disposal, which is harmful to the natural environment, reduce extraction of virgin material, which depletes natural resources, and simultaneously improve economic efficiency.

Implementing the CE remains very difficult. Firms struggle to *initiate* and *sustain* waste exchanges; using another firm’s waste stream as input for production appears to be particularly challenging. In the past decade circularity brokers such as the *Centre for the Transfer of Technologies in Industrial Ecology* (CTTÉI) have contacted thousands of firms across sectors to broker diverse waste exchanges (Paquin and Howard-Grenville, 2013; Ciulli et al., 2019). In spite of proven economic viability and active facilitation, only 40% of the contacted firms *initiate* a waste exchange and only 15% of them are able to *sustain* the exchange over time (Paquin et al, 2014).

In order to successfully source and use another firm’s waste stream, the opportunity must first be recognized, then an enduring operational process must be established. Neither step is easily done because the ability to see value in a waste stream is non-obvious (de Jesus, and Mendonça, 2018) and the operational process must be extremely agile to accommodate high levels of volume and quality variability (Dhanorkar et al., 2019).

The broad question motivating this research are:

- (Micro-level of analysis) Managerial cognition: How can we help managers to recognize value in waste?
- (Meso-Level of agility) Operational agility: under what conditions can firms productively integrate the waste of other firms into their supply chain operations?
- (Macro-Level of analysis) How to govern secondary markets and reverse supply networks within a localized, resilient circular bio-economy?
- (Macro-Level of analysis) What institutional conditions stimulate innovation and organic growth to support the rapid emergence of a circular bio-economy?

My team and I have already collected and analyzed data about 30+ food waste exchanges within the City of Montreal. In the following pages I present:

- A summary table of a sub-set of these waste exchanges;
- A simplified map of how these waste exchanges intertwine with linear supply chains;
- A one-page summary for a sub-set of these waste exchanges.

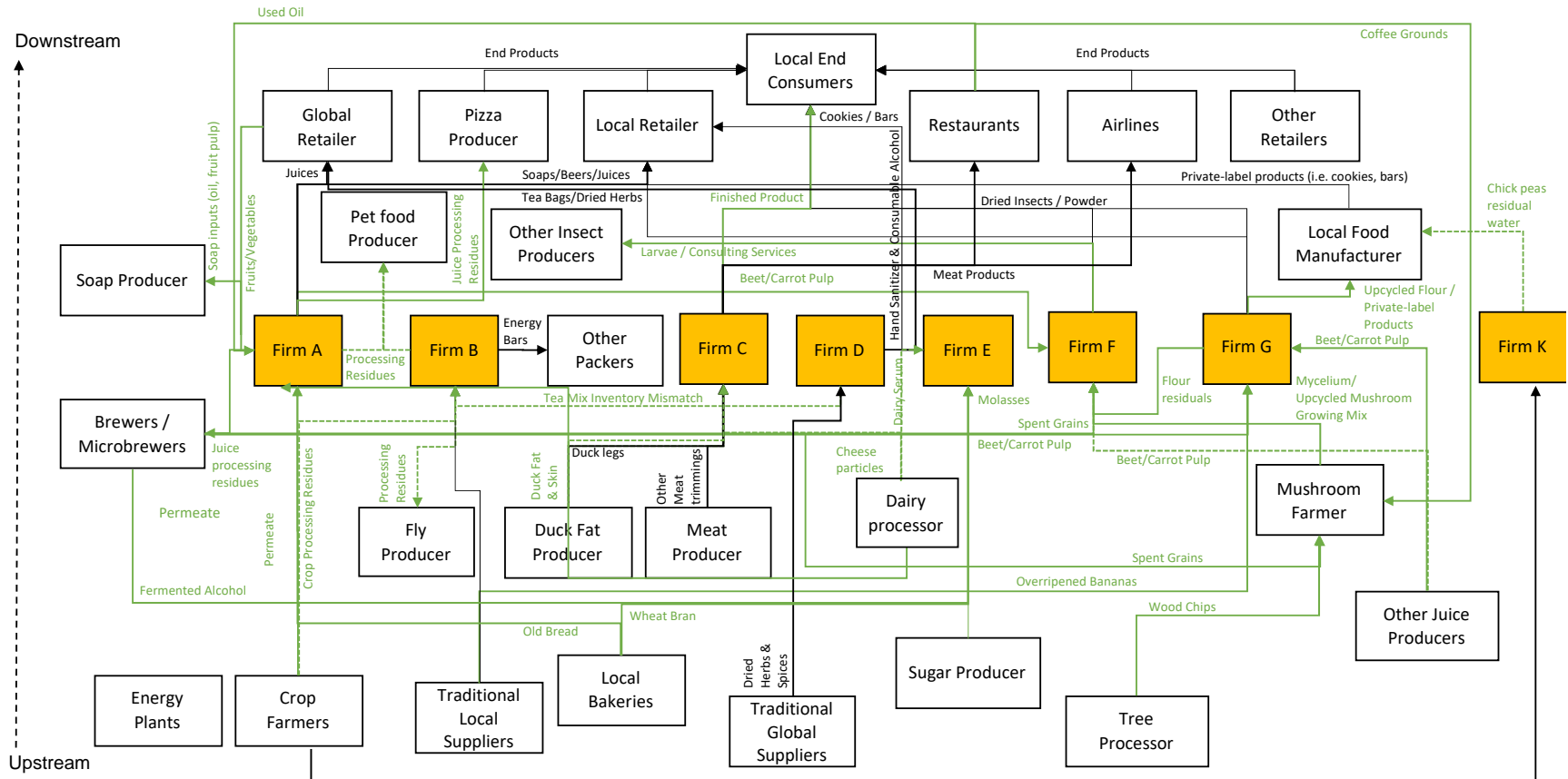
We would love to collaborate with City of Montreal to deepen our forensic study of the emergence and functioning of a local, resilient circular bio-economy.

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Table 1: Case and Synergy Summaries***Grouped by firm.*

Case/ Synergy ID	Firm ID	Firm size	Basic Synergy Summary (X by-product/surplus for Y product)	Geography
1	A	Small	Fresh fruits/vegetable for fresh-pressed juices	Montreal, QC
2	A	Small	Bread surplus for beer production	Montreal, QC
3	A	Small	Used oil for soaps	Montreal, QC
4	A	Small	Lactose permeate from dairy	Montreal, QC
5	B	Medium	Evaluating the adoption of flour, produce, and dairy for various bars	Châteauguay, QC
6	C	Medium	Duck trimmings for meal preparation	Saint-Hyacinthe, QC
7	C	Medium	Evaluating cheese by-product for meal preparation	Saint-Hyacinthe, QC
8	D	Medium	Evaluating fruit pulp for teas	Saint-Bruno, QC
9	E	Small	Molasses for alcohol	Granby, QC
10	E	Small	Dairy serum and permeate rich in lactose sugars for alcohol	Granby, QC
11	F	Small	Mycelium for insect feed	Montreal, QC
12	F	Small	Upcycled mixture from mushroom growth for insect feed	Montreal, QC
13	F	Small	Pear pulp for insect feed	Montreal, QC
14	F	Small	Cantaloupe pulp for insect feed	Montreal, QC
15	F	Small	Apple pulp for insect feed	Montreal, QC
16	F	Small	Kale pulp for insect feed	Montreal, QC
17	F	Small	Celery pulp for insect feed	Montreal, QC
18	F	Small	Carrot pulp for insect feed	Montreal, QC
19	F	Small	Beet pulp for insect feed	Montreal, QC
20	F	Small	Spent grains for insect feed	Montreal, QC
21	F	Small	Wheat bran for insect feed	Montreal, QC
22	F	Small	Upcycled flour for insect feed	Montreal, QC
23	G	Small	Spent grains for flour / cookies / bars	Montreal, QC
24	G	Small	Beet pulp for cookies / private-label products	Montreal, QC
25	G	Small	Carrot pulp for cookies / private-label goods	Montreal, QC
26	G	Small	Apple pulp for cookies / private-label products	Montreal, QC
27	G	Small	Bananas for cookies	Montreal, QC
28	K	Large	Aquafaba	Montreal, QC
29	L	Large	Grain Husk for animal feed	Montreal, QC
30	L	Large	Spend Yeast for xxx	Montreal, QC

Figure 1: Simplified illustration of emergent circular bio-economy in the Montreal Metropolitan Area.



| Case 1: Firm A, Québec - Organic produce for juice

Sourcing firm:

Size (employees): Over 25 employees

Annual revenue: N/A

Maturity: Start-up

Location: Montréal, QC

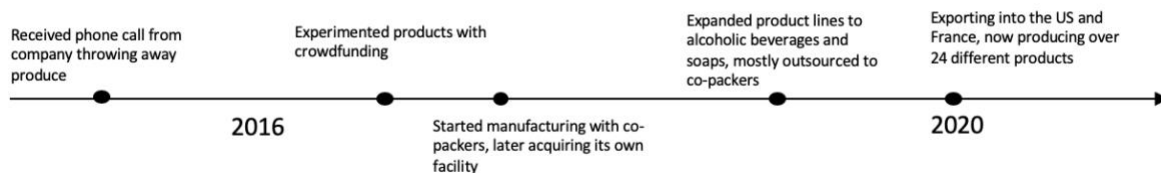
Firm A is currently a food recovery and transformation business that specializes in sourcing food waste and transforming it into juices, soaps, and alcohol. Firm A itself is also a resource generator as it has started selling its own waste to downstream partners, such as pet food manufacturers. Currently the firm produces over 24 varieties of juices, soaps, and alcoholic drinks. All products are made in-house and are sold to retailers, restaurants, and supermarkets across North America and Europe.

Material(s) & Synergy Supplier(s) Involved

For its juice production, Firm A uses wasted produce, such as a surplus of mangoes, celery, avocados, strawberries, clementine, that might be traditionally wasted due to aesthetic and product life preferences. The firm's primary supplier is a major distributor of fruits and vegetables in Montréal, who they have a very close relationship, as their largest supplier is also an investor into their operations, holding board seats in the organization. Seasonality is a major source of variation of the volume and quality of this produce.

Timeline of Synergy Recognition and Integration

General Timeline of Firm



Firm A was founded with a crowdfunding campaign to test the market with some experimental juices, realizing online success. The founder stated that since he already possessed expertise in the food and beverage industry, a market study was deemed unnecessary. Firm A then started producing juices with a co-packer to send its products to market while minimizing capital costs, but now has its own factory to press juices. The decision to in-source the pressing is due to the foundation of fruit juices being a foundational part to most of their products, as well as to take the most advantage of the short-shelf life that the fruits have that. To also minimize seasonal variety, the firm freezes some of its fruit to create approximately a six-month buffer inventory.

Synergy Proficiency

High: Recycled products account for 100% of its product portfolio. One of their first rounds of funding was approximately \$250,000.00 and joined in on investments with their supplier, who has a seat on their board. Their initial marketing costs were low, but highly successful in attracting both suppliers and consumers.

| Case 2: Firm A, Québec - Bread surplus for beer

Sourcing firm:

Size (employees): Over 25 employees

Annual revenue: N/A

Maturity: Start-up

Location: Montréal, QC

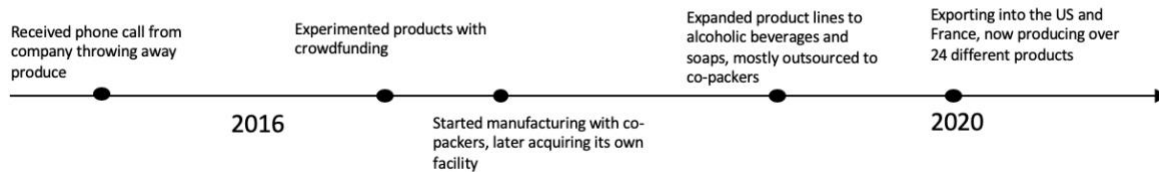
Firm A is currently a food recovery and transformation business that specializes in sourcing food waste and transforming it into juices, soaps, and alcohol. Firm A itself is also a resource generator as it has started selling its own waste to downstream partners, such as pet food manufacturers. Currently the firm produces over 24 varieties of juices, soaps, and alcoholic drinks. All products are made in-house and are sold to retailers, restaurants, and supermarkets across North America and Europe.

Material(s) & Synergy Supplier(s) Involved

For its beer production, Firm A sources a surplus of older bread that may not be marketable as is to end consumers. The firm's primary suppliers for bread are local bakeries. There is minimal variation to this material, as there is a steady supply in volume and the variation in quality does not seem to be a concern.

Timeline of Synergy Recognition and Integration

General Timeline of Firm



Firm A uses a co-packer for its beer production and is looking to capitalize on a certain degree of first-movers advantage in this upcycling space to replicate its local model quickly. The decision to outsource its alcohol production is to focus on the company's core competencies.

Synergy Proficiency

High: Recycled products account for 100% of its product portfolio. One of their first rounds of funding was approximately \$250,000.00 and joined in on investments with their supplier, who has a seat on their board. Their initial marketing costs were low, but highly successful in attracting both suppliers and consumers.

| Case 3: Firm A, Québec - Used oil for soaps

Sourcing firm:

Size (employees): Over 25 employees

Annual revenue: N/A

Maturity: Start-up

Location: Montréal, QC

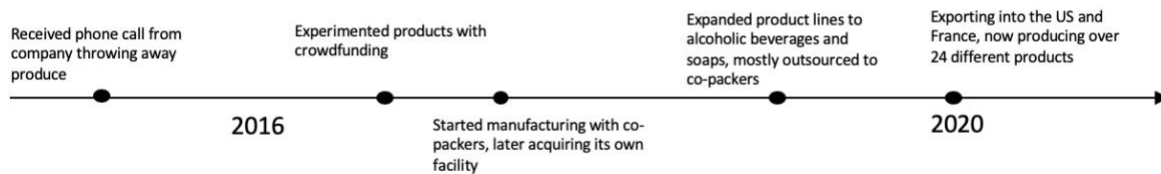
Firm A is currently a food recovery and transformation business that specializes in sourcing food waste and transforming it into juices, soaps, and alcohol. Firm A itself is also a resource generator as it has started selling its own waste to downstream partners, such as pet food manufacturers. Currently the firm produces over 24 varieties of juices, soaps, and alcoholic drinks. All products are made in-house and are sold to retailers, restaurants, and supermarkets across North America and Europe.

Material(s) & Synergy Supplier(s) Involved

For its soap production, Firm A sources used oil from restaurants. From learning more about this process, there is limited variation in the oil that can be converted into soap. This also applies to volume variation, as there is a steady supply for used oil in the area.

Timeline of Synergy Recognition and Integration

General Timeline of Firm



Firm A uses a co-packer for its soap production. The decision to outsource the soap manufacturing comes from the desire for the company to remain focused on their core competencies.

Synergy Proficiency

High: Recycled products account for 100% of its product portfolio. One of their first rounds of funding was approximately \$250,000.00 and joined in on investments with their supplier, who has a seat on their board. Their initial marketing costs were low, but highly successful in attracting both suppliers and consumers.

| Case 4: Firm A, Québec - Organic produce for beer

Sourcing firm:

Size (employees): Over 25 employees

Annual revenue: N/A

Maturity: Start-up

Location: Montréal, QC

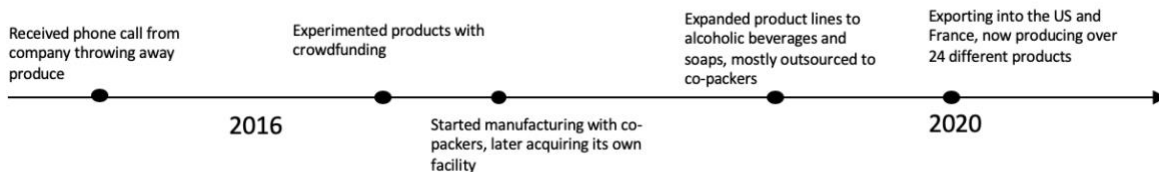
Firm A is currently a food recovery and transformation business that specializes in sourcing food waste and transforming it into juices, soaps, and alcohol. Firm A itself is also a resource generator as it has started selling its own waste to downstream partners, such as pet food manufacturers. Currently the firm produces over 24 varieties of juices, soaps, and alcoholic drinks. All products are made in-house or by copackers and are sold to retailers, restaurants, and supermarkets across North America and Europe.

Material(s) & Synergy Supplier(s) Involved

The main material involved in this synergy is the permeate which is a sugar rich liquid and is a by-product of the milk production units. It is a transparent, bright yellow liquid and it has 85% of lactose solids and others are minerals and it tastes like milk. Firm J supplies this by-product for production of milkshake beer. Firm J is a large Dairy Cooperative in Ville St-Laurent, Quebec. Firm A uses a co-packer for its beer production, and they have 3 brands of milkshake beers made with permeate and it is made by replacing the water in the beer production with permeate. The volume supplied is 70,000 litres a year. Firm J produces these by-products in large quantities and hence they are looking at this synergy as a non-permanent solution and they are constantly looking for more sustainable and one-time solution through in-house R&D. Firm J was initially supplying this permeate in a dried form to pig farms in Asia. In 2018 there was disruption in this supply chain due to a disease outbreak in farms. Previously 85% of the permeate was exported and the production of permeate is growing. Approximately 1-10 million litres of surplus permeate was discarded by the plant in Montreal alone every year and that is the reason they are looking for players to buy this product.

Timeline of Synergy Recognition and Integration

General Timeline of Firm



Synergy Proficiency

High: Recycled products account for 100% of its product portfolio. One of their first rounds of funding was approximately \$250,000.00 and joined in on investments with their supplier, who has a seat on their board. Their initial marketing costs were low, but highly successful in attracting both suppliers and consumers.

| Case 5: Firm B , Québec - Evaluating the adoption of flour, produce, and dairy for bars

Sourcing firm: Firm B

Size (employees): Over 70 employees

Annual revenue: N/A

Maturity: Established Company

Location: Châteauguay, QC

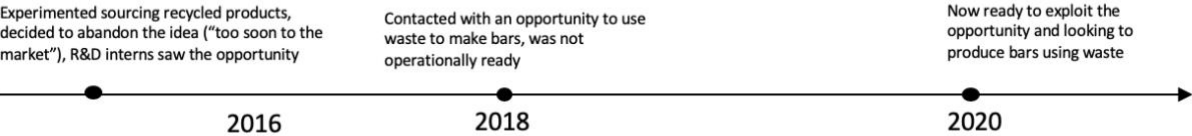
Firm B is a private-label bar manufacturer and co-packer founded in 2001 under five key values: Professionalism, Engagement, Respect, Flexibility, and Innovation. Originally operating as a manufacturer of marshmallow squares, they diversified their products by offering customized bars and focusing on 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.

Material(s) & Synergy Supplier(s) Involved

Currently, Firm B is looking to source multiple types of waste, including fruits, vegetables, flour, and dairy products. They are currently looking for local suppliers in the region for this synergy.

Timeline of Synergy Recognition and Integration

General Timeline of Firm



Firm B emphasizes R&D collaboration by encouraging interns and other staff to look for industry trends for new types of bars and other products. These ideas are then voted on unanimously during cross-department meetings. This has allowed the firm to become more aware of the waste that is being produced and the circular practices that can be integrated. In order to be prepared to take advantage of these practices, the firm has recently invested in structural components, such as machinery and a larger facility that can be more customizable to accommodate different types of ingredients. This is essential for the firm, as they produce custom recipes for their clients. They also have one designated person that will be overseeing these types of potential synergies, which will provide the firm more capacity to discover and integrate synergy opportunities.

Synergy Proficiency

Medium: Invested and moved into a larger facility this year and are currently evaluating the adoption of flour, produce, and dairy in various bars. Firm B still needs to alleviate organizational constraints to fully implement its ideas.

| Case 6: Firm C, Québec - Meat by-products for recipes

Sourcing firm: Firm C

Size (employees): Over 50 employees

Annual revenue: N/A

Maturity: Medium sized start up

Location: Palencia, Spain and Saint-Hyacinthe, Québec

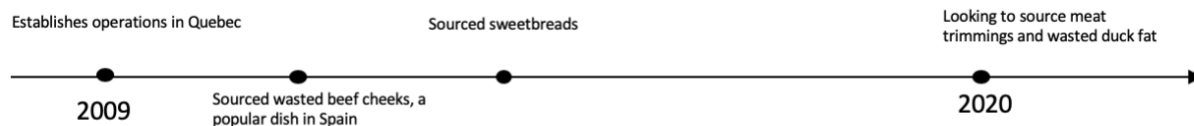
Firm C was founded by two Spanish entrepreneurs who wanted to provide high-end, semi-processed meat products to local hotels, restaurants, and other institutions. Their products are cooked sous-vide and are required to follow many food safety regulations.

Material(s) & Synergy Supplier(s) Involved

Meat by-products, such as trimmings like the skin from duck legs, have been sourced from a local supplier in order to create a line of meatballs. The firm sources from an existing supplier of duck legs, where they are looking at potentially purchasing by-products from their duck fat melting process to incorporate into their other recipes. The firm maintains a close relationship with its supplier, actively visiting and finding new ways to collaborate. Currently, Firm C is examining opportunities to source and process wasted duck fat from other food processors in its own products. There are restricting challenges working with these types of food products, namely regulations that the firm needs to abide by.

Timeline of Synergy Recognition and Integration

General Timeline of Synergy – Meat by-products



The firm emphasizes the close proximity to their suppliers as the main reason to recognize these opportunities and to maintain trusting relationships to collaborate and negotiate to implement this synergy. As the meat trimmings, namely the skin that is used to melt down into fat, was considered a waste product from regulatory bodies, this classification initially presented barriers for the firm to use it as an input for its products. The synergy is now being presented to customers to see if there is demand for these recipes. For their private-label products, the firm is more limited in altering the product recipes as they need to follow the designated preferences asked by their clients, making these types of presentations integral to gaining interest for these new recipes.

Synergy Proficiency

Medium-High: Duck fat and meat trimmings are currently sourced and used into 5-10% of the product offerings and is sourced at wholesale prices. The main time delay for this synergy was getting approval from regulatory bodies. The synergy was able to be integrated rather seamlessly, as the company has a team of food scientists that were able to leverage their knowledge of these ingredients into the product design.

| Case 7: Firm D, Québec - Cheese by-products for recipes

Sourcing firm: Firm C

Size (employees): Over 50 employees

Annual revenue: N/A

Maturity: Medium sized start up

Location: Palencia, Spain and Saint-Hyacinthe, Québec

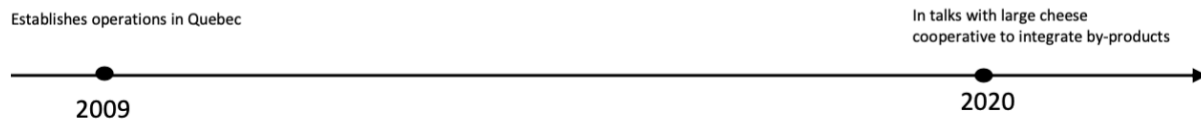
Firm C was founded by two Spanish entrepreneurs who wanted to provide high-end, semi-processed meat products to local hotels, restaurants, and other institutions. Their products are cooked sous-vide and are required to follow many food safety regulations.

Material(s) & Synergy Supplier(s) Involved

The main material involved in this synergy are cheese particles, which are a by-product of cheese production. The main supplier involved in this synergy is a large cheese cooperative near the firm's facilities. The variation in quality is not apparent, but the volume would be consistent, as there is a large available supply year-round. Additionally, as the supplier is in a close proximity to the firm, variation from transport would be limited.

Timeline of Synergy Recognition and Integration

General Timeline of Synergy – Cheese by-products



Due to the large scale of the supplier, the main challenge for integrating this stream into their operations is that they lack the bargaining power and internal capabilities to deal with the large volumes from the supplier. The supplier may not believe this synergy may be worth it, as the costs of arranging logistics to transport this by-product may be too high for the low volume that would be involved. Thus, the supplier may not perceive the synergy as financially beneficial for them, as they are not yet able to leverage economies of volume through this exchange.

Synergy Proficiency

Low: The cheese particle exchange has been considered for the past few months and is still being considered, but the mis-match of scale is the main barrier to integrating this synergy alone.