Milk in a Bag: The Hidden Cost of Dairy Subsidies[1]

"Government controls constrain and constrict; they rearrange and repattern the structure of incentives; they redistribute incomes and wealth and sharply modify both the processes of production and the composition of consumption" – Kirzner (1979, 134-135)

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Abstract

Why does milk come in cartons or jugs but not plastic bags? These pouches have lower costs of production and a smaller carbon footprint, along with high levels of toughness. Through a comparative analysis of dairy subsidies across Canadian provinces, I argue that milk no longer comes in plastic pouches because of dairy regulations, adding another example to the unintended consequences of regulation (Kirzner 1979). Support prices for different classes of milk also distort the market, resulting in higher prices for fluid milk and larger firms. Larger economies of scale in cheese and butter production increase the average distance between a processing plant and a grocery store, making paperboard and plastic jugs more cost-effective even though they cost more to manufacture and dispose of. Regions without effective price ceilings on milk production quotas do not have milk in plastic pouches; fluid milk comes in plastic jugs or paperboard cartons instead.

Keywords: Dairy subsidies, environmental economics, agricultural policy, packaging
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1. Introduction

Why does milk come in cartons or jugs, but not bags? These opaque pillow pouches have lower costs of production, along with lower carbon emissions and costs of disposal. In landfills, pouches take up less space than an HDPE jug, which takes up less space than a flattened carton. Even though pouches have lower costs of packaging and recycling, they never caught on in the American market despite significant marketing. Most consumers claim that they do not care whether a container is transparent, and milk preserves better when not exposed to ultraviolet light (While 1985). However, stores in Canada, India, South Africa, Columbia, the U.K., and Iran all sell milk in a bag (Sun et al. 2021; Daneshi et al. 2014). Even though only 7 percent of milk comes in pillow pouches in North America[3], it constitutes a large share of packaging in Mediterranean Africa (72 percent) and the former Soviet Union (54 percent (Sun et al. 2021, 2).

Introduced in 1967 by DuPont in Canada, milk pouches gained popularity with various dairy companies, especially after Canada switched from imperial to metric units in 1975. The costs of changing the size of a package were lower for plastic bags than for cartons and HDPE jugs. Cartons and plastic HDPE jugs require molds and specialized machinery for production, so the costs of altering their sizes are higher (Hayek 1935). In America, milk bags are only used in convenience chain stores that have their in-house dairies, typically in the Midwest states such as Wisconsin (Migiro 2019).

Even though every province used to provide milk in a bag, the Western provinces of Canada (Alberta, British Columbia, Saskatchewan, and Manitoba) do not use milk pouches.

[3] The US heavily skews the percentage towards cartons and HDPE jugs because of the higher per capita milk consumed relative to Canada (255 kg/capita vs. 188 kg/capita) along with a larger population (Shahbandeh 2022a, 2022b). Milk typically does not come in a bag in the US, so the percentage of milk that comes in pillow pouches is extremely low for North America (World Population Review 2023).

Instead, all milk comes in an HDPE jug or carton (Sun et al. 2021, 8). Ontario and Quebec account for over 60 percent of all milk production in Canada, and milk in a bag is a common fixture in grocery stores. Coincidentally, the western provinces do not have price ceilings on milk production quotas: they can be traded freely at prices set by supply and demand. I do not include Newfoundland and Labrador in my paper because it only constitutes 0.6 percent of all milk production in Canada, and they use different units of measurement for quota (Government of Canada 2021). They also only have 25 dairy farms and two dairy processors, a far cry from the hundreds or thousands of dairy farms spread across other provinces (Government of Canada 2023; Government of Newfoundland and Labrador 2018).

In this paper, I argue that milk comes in plastic jugs or paperboard cartons because of dairy regulations, creating distortions in the market and increasing carbon emissions. Each dairy farm needs to purchase quota from the province. These quotas may or may not be traded between farms within the same province, depending on the provincial policy. Cross-provincial trades rarely occur, as the Canadian Dairy Commission (CDC) determines the total milk production quantities, after which they allocate a proportion to each province. In provinces where the quota can be freely traded according to supply and demand, milk only comes in cartons or jugs. New entrants must buy a certain quantity of quota, which could cost as much as 20 times the price of a cow (Government of Canada 2023). On the other hand, milk still comes in bags in provinces that have an effective price ceiling on quotas. Most dairy farmers can afford an additional unit of quota at the price of $24,000, but few farmers are willing to sell: the success rate of a bid is between 0.9 percent to 6 percent (Government of Canada 2018, 2022) Regardless of price controls, quotas erect entry barriers and increase the economies of scale. Milk in a bag has lower per-unit costs of production, but hits diminishing marginal returns much earlier. Thus, price

ceilings on quotas change the structure of the dairy industry, which affects packaging and the environment.

This paper contributes to the consequences of interventionism and environmental economics. I do not prescribe a certain policy or make normative claims on the merits of various dairy regulations: I simply demonstrate that dairy quota regulations are incompatible with environmental policies implemented by the government. After a brief review of the literature, I describe current state of affairs in the Canadian dairy industry. Subsequently, I survey the various materials that could hold dairy products, and I conclude with empirical evidence on the size of dairy farms. In the last section, I conclude.

2. Literature Review

Intervention in the free market often leads to unintended consequences. It tends to "interfere harmfully in the *entrepreneurial process* [emphasis preserved]," even when assuming that the regulation was introduced with a public good in mind (Kirzner 1979, 126). Markets "nudges prices in the direction of equilibrium," so competition keeps the market in motion (128). Prices do not simply change by themselves with a "series of successive trials;" someone or something has to set it in motion (127). Government officials cannot know whether the "imposed prices might evoke the 'correct,' desired actions by market participants" (139).

Canada is one of the few countries that has kept a dairy supply management policy: many countries such as Australia, the United Kingdom, South Korea, and the European Union have phased out their programs. The Canadian Milk Supply Management Committee (CMSMC), chaired by the Canadian Dairy Commission (CDC), assesses the demand for milk and implements a quota system to control domestic milk production. It restricts foreign competition

through high tariffs on dairy products above Canada's WTO minimum access commitments (Meilke and Cairns 2011). The CDC also sets the farm gate price, which is the price that dairy farmers may sell to dairy processors. They determine the price based on a cost of production formula and "classified pricing, by end-use, of milk purchased for processing" (Meilke and Cairns 2011, 1; Jelinski et al. 2015, Charlebois et al. 2021; Scullion 2006).

Subsidies change input use, labor allocation, production choices, and investment in an industry (Guyomard et al. 1996; Hennessy 1998; Sckokai and Moro 2009). Dissatisfaction with market outcomes tends to give rise to government regulations, which "rearrange and repattern the structure of incentives, redistribute incomes and wealth, and sharply modify both the processes of production and the composition of consumption" (Kirzner 1979, 135). Market outcomes could simply reflect "inescapable scarcity" and the preferences of the consumers, not the elite (135). According to Kirzner, market outcomes may be unfavorable due to earlier government interventions, and the government has been intervening in the Canadian dairy market since the 1940s (1979; Scullion 2006). Agricultural markets are inherently unstable as the price of output depends on a variety of factors, and food prices tend to be more volatile than the quantity of output (Boussard et al. 2006; Gouel 2014; Graddy-Lovelace and Diamond 2017). A decrease in farm gate prices often does not get passed on to the consumer as processors and distributors capture most of the price difference, especially for products that face a relatively inelastic demand (Royer 2008). Support prices also create a stable environment for investment: the costs of production will always be covered by the government (Tamini et al. 2018). However, Canadian farms are considerably smaller than their counterparts in New Zealand or the US (Mundler and Ruiz 2018). In 2017, provinces that had a price ceiling on quota had an average of 86 cows per farm, while provinces without a price ceiling had an average of 156 cows on each

farm. When aggregated, Canadian farms had an average of 117 cows in each (Government of Canada 2023). In contrast, the US has an average of 173 cows per dairy farm, and New Zealand has over 300 (King 2021).

Quotas create barriers to entry, and the price ceiling on them generates artificial shortages. Upfront costs of quota discourage new entrants and concentrate quota in large farms, which can afford to pay for additional units of quota (Geloso et al. 2017; Richards 1996; Finlay 2012). New entrants could replace several high-cost producers with one low-cost producer, but quotas do not allow new entrants to produce more than their proportion. Price ceilings also inhibit the "discovery of as of yet unsuspected sources of supply" or new products (Kirzner 1979, 143). Critics of the Canadian dairy management system point out that farmers cannot supply niche products such as organic or raw milk because they cannot directly bring goods to the market, and dairy processors make more selling conventional milk (Mundler et al. 2020). These quotas also lead to market distortions that protect inefficient producers (Veeman 1982). They also hamper the restructuring of the industry, reduce competition within the field and for the field, and prevent producers with lower costs of production from expanding their output (Finlay 2012). Because demand for fluid milk is relatively inelastic, low-income customers disproportionately bear the costs of higher prices of milk (Cardwell et al. 2015; Desrochers et al. 2018). Additionally, producers cannot export their products because they cannot produce above domestic demand (Barichello et al. 2009; Carter and Mérel 2016).

The persistence of regulations can be explained by the transitional gains trap. Government programs that help one industry or group get fully capitalized after a certain period of time, so producers in the industry do not earn extraordinary returns (Tullock 1975, 671). Taxicab medallions in New York City restricted the supply of taxis, so players in the market

earned a monopoly profit. New entrants had to purchase the medallion, so they would only earn normal profits. Another example Tullock uses is that of the Agricultural Adjustment Association. The AAA bought livestock and paid farmers to not plant certain crops so that the price of those crops could rise (Anderson 1936). Gains in the value of farm products were "quickly capitalized into the value of land" (Tullock 1975, 675). Owners of farmland at the time made "immense gains," but subsequent owners did not (675). Ending the quota program would mean large losses for current dairy farmers, who paid between $24,500 to $58,000 (Canadian dollars) for a unit for quota (Tullock 1975, 671; Government of Canada 2023). Each unit of quota allows a producer to produce a kilogram of butterfat a day, roughly the output of a cow each day. In Canada, the dairy lobby wields a lot of power (Stewart 2022). The costs of these quotas are supposedly borne by those in the industry, such as producers, processors, distributors, and consumers. However, every regulatory policy has unintended spillover effects. These subsidies and quotas affect the distribution channels and packaging decisions of dairy processors. As farms get larger, the mean transportation distance for raw milk to dairy processors and grocery stores implies that packaging has to change. What may work for short distances may prove too costly for longer distances. This paper shows how subsidies change the relative prices of milk and increases the carbon footprint generated by packaging in the dairy industry.

Much ink has been spilled on packaging. Since solid waste is a "major problem of society," environmentalists have targeted various disposal policies (Singh et al. 2014, 347). Defined as useless, unwanted, or discarded material with low-liquid content, solid waste typically ends up in a landfill. Product packaging has a "significant global environmental impact," through energy use, greenhouse gas emissions, and water consumption (Sun et al. 2021). Almost all milk is sold in single-use packaging, and the Canadian government aims to ban

single-use plastics by 2030, such as plastic checkout bags, stir sticks, six-pack rings, cutlery, and food ware made from plastics that are harder to recycle (Environmental and Climate Change Canada 2020).

Environmental concerns about dairy product packaging have “generated more laws, regulations, consumer actions and reaction, and media discussion than the combined total of all other issues, even safety… for the past decade” (Brody 2016, 518). Ironically, plastic from dairy products only makes up 10 percent of the weight of packaging and 20 to 25 percent of the solid waste volume (519). Pillow pouches have a lower carbon footprint than jugs or cartons, along with taking up a smaller volume in a landfill (Sun et al. 2021). Alberta, Saskatchewan, and British Columbia have instituted a container deposit recycling system, where consumers pay marginally more for dairy products that come in a carton or jug. They can get a refund if they take the products to a recycling station (Pawson 2022; Bottle Bills 2022). Coincidentally, the three provinces are part of the Western Milk Pool, where milk no longer gets sold in a bag. Manitoba is the only non-participator that is part of the Western Milk Pool, and they justify it by appealing to their higher rates of recycling and a desire to keep prices low (Sustainable Transportation 2019). Most other provinces have deposits on alcoholic drinks or soft drinks, but exempt dairy products from the list. Milk often comes in a bag for them.

3. Canadian Milk Market

The Canadian milk market used to have two kinds of producers: industrial and fluid milk. The latter gets packaged and goes directly to the market, typically commanding a higher price per liter. Industrial milk is used to make cheese and butter, along with creams and milk powder. Cream farms separate cream from the milk, which is then made into skim milk powder. The

cream is used to make butter. Throughout the 1940s and 1950s, Canada subsidized fluid milk so that consumers could afford to buy milk. In 1958, the Canadian government enacted the Agricultural Stabilization Act to "support the price of butter and cheese (and other commodities) at not less than 80 percent of the previous 10-year market or base price," hoping to increase exports (Scullion 2006, 8). The Agricultural Stabilization Board would buy butter from processors during peak season at the support price ($0.25/cwt or $0.57/hl), store it for free, and sell it back to the producers in the off-season for the same price. Fluid producers who sent their excess milk to the industrial market did not qualify for the subsidy. These subsidies indirectly increased the price of industrial milk because processors using milk for other dairy products would have to pay higher than the support price. In turn, the price of cheese and butter increased; imports became cheaper.

Starting in the 1960s, Canada has a system called the Subsidy Eligibility Quota. Farmers could receive a subsidy on milk shipments up to his amount of quota. Excess fluid milk then went to the industrial market, made into cream and milk powder (Scullion 2006, 32). Industrial milk shippers would receive at least the support price, while fluid milk producers would simply get the market price for their excess industrial milk. Thus, larger fluid milk farmers would produce their subsidized quota of fluid milk, and sell the rest as industrial milk, which kept industrial milk prices relatively low. Industrial milk producers did not like the system because they still faced "low milk prices," while their counterparts in the fluid milk industry earned higher profits (19). Around 10,000 Quebec and Ontario dairy farmers marched to Parliament Hill in 1967 to express their discontent. At that time, Quebec and Ontario made up close to three-fourths of all milk production in Canada (Scullion 2006, 9). British Columbia had converted all production to bulk milk tanks by the end of the 1960s through government mandate, which

forced out all marginal producers and “almost all cream shippers” (Scullion 2006, 10). In contrast, only 8 percent of all industrial and cream farms had bulk milk tanks in Ontario and Quebec.

In response to farmer discontent, quotas were established in 1971. They promised to “effectively safeguard farmer revenues, promote market stability, and ensure that prices adequately compensated producers without the need for further subsidies” (Mundler et al. 2020, 263; Gouin & Kroll 2018; Hiscoks 1973). Chicken, egg, and turkey production also went under a quota system, but they have higher exemption levels. For example, one could sell 99 to 2,000 chickens depending on the province before needing to buy quota. Alberta has an exemption of 50 liters (13 gallons) per day, slightly less than the production volume of two cows. None of the other provinces have an exemption. Existing dairy farms at the time received a proportion of quota based on their size and past production. Each province received a percentage of national quota, which is divided by proportion to various farms. Every year, individual quota is adjusted “based on their share of provincial allotment from the preceding period” (Mundler et al. 2020, 263; Katz et al. 2008). If demand for dairy products rises, the annual quota for the next year increases, with the additional quota distributed proportionately across the provinces (Mundler et al. 2020, 263). The policy does not take into comparative advantages of production, and the increase in supply lags behind an increase in demand.

As part of the quota regulation, the two milk pools had to be integrated, a compromise between fluid and industrial milk producers. Fluid milk producers had to incorporate industrial milk producers into their pools to receive the industrial milk subsidy as well. Provincial board pooled returns from each different class of milk, and paid producers a “blend price” that they received from various processor buyers (Scullion 2006, 44). As a result, fluid producers started

producing more industrial milk as both counted equally towards a producer's quota, and they could get the industrial subsidy as well. In 1975, four years after the introduction of the quota system, the Canadian Milk Supply Management Committee (CMSMC) announced the Returns Adjustment Formula, which incorporated costs of production into the support price. Indices of dairy production costs had a 45 percent weight, milk production labor costs indexed by the CPI had a 35 percent weight, and the last 20 percent was an "undefined discretionary factor," which was never used in practice (Scullion 2006, 50). Industrial milk target prices rose by 10 percent, and the target price of yesteryear became the new support price. In the subsequent year, industrial milk flooded the market and the government had to store all the excess milk according to the agreement. To bring milk production back to the "current market requirements," the CMSMC cut available quota by 18 percent (Scullion 2006, 54). Around 10,000 farmers marched on Parliament Hill and dumped milk on the Minister of Agriculture, Eugene Whelan, when he tried to talk to them (Scullion 2006). To "quell the turmoil," the Minister of Agriculture added 4 percent back in, but the additional quota went to those who were the "hardest hit" by the changes (Scullion 2006, 58). But the makeup of milk production shifted: industrial milk production became more lucrative than producing fluid milk.

Compounded by a decrease in consumer demand for fluid milk due to an increase in the popularity of soft drinks, producers started producing more industrial milk to be made into cheese, butter, yogurt, and cream. Cheese and butter production requires large, steady amounts of milk, favoring commercial dairy farms with hundreds of dairy cows. Larger operations have a lower marginal cost of production due to economies of scale, so they can afford to buy more quota, further expanding their production. Empirically, producers in Ontario with large economies of scale were more likely to buy additional quota each year, and older producers were

less likely to purchase quota (Elskamp and Hailu 2013). As dairy farming in Ontario does not differ significantly within the five eastern provinces, the same effect should hold in other ones.

Quota may be exchanged within provinces. When first allocated, quota did not have much value, but its value has increased dramatically since the mid-1980s (Meilke and Cairns 2011). A unit of quota cost about $15,000 in the mid-1990s, rising to $30,000 in 2004 (constant 2006 dollars), which is an annual increase of 11.7 percent each year (Meilke and Cairns 2011). Due to low interest rates and stable agricultural policy, potential entrants have less uncertainty about the return on investment, and they can borrow the capital needed to purchase quota.

In response to the rising prices of quota, the five eastern provinces also known as the P5 (New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island, Quebec, and Ontario) imposed price ceilings on milk production quota. In 2005, the Dairy Farmers of Ontario (DFO) enacted a variable in-kind tax on producers selling quota, limiting the amount a producer received at $25,000 per unit. They assumed that “speculative behavior was driving the spike in quota prices” so they imposed a price ceiling of $25,000 with scheduled monthly reductions to $24,000 per unit by January 2010 (Meilke and Cairns 2011). The Ontario Milk Board gets a 10 percent commission on the trade of quota, and the binding price ceiling sharply decreased the volume of trade occurring. Thus, the price ceiling hurts the revenue of the Ontario Milk Board, even though it stabilizes the price of quota (Painter 2007).

Provinces in Western Canada did not limit the price of quotas. In December 2022, quota costs ranged from $48,4000 in Alberta to $35,530 in Manitoba (Government of Canada 2023). Alberta had the highest cost for quota, and coincidentally the smallest average herd size among the Western provinces. Notwithstanding high quota costs, average herd size in these provinces increased “much more rapidly than in Quebec and Ontario” (Jelinski et al. 2015). Between 2012

and 2022, Manitoba's average herd sizes have increased by close to 50 percent while herds in Ontario and Quebec have only increased by 25 percent.

Small farmers and new entrants face significant costs in the dairy market (Mundler et al. 2020). New farmers tend to rely on local outlets to sell their products, but they cannot enter the market because they do not own quotas (Laforge et al. 2018). Dairy producers in Ontario who bid for new quota have a success rate between 0.8 to 3 percent. In recent years, Ontario and Quebec have started programs that favor new entrants, but someone has to sell quota for them to buy. Prince Edward Island, Manitoba, New Brunswick, Nova Scotia, Ontario, and Quebec all have a quota minimum of 10 kilograms of butterfat each day, British Columbia requires 4.1 kilograms, while Saskatchewan and Alberta have no minimums (Mundler et al. 2020). Newfoundland and Labrador has a minimum production requirement of 500 liters of milk per day, which is between 20 to 25 kilograms of butterfat. Thus, the quota costs and minimum prove significant to new entrants.

4. Packaging in the Dairy Industry

As dairy farms get larger, the time between milk production to when it gets to the grocery shelf increases. Packaging today costs less than 10 percent of the sticker price of the item, including fixed costs such as capital expenditures for equipment and plant costs. Packaging must “protect the product from the point of manufacture through their consumption” (Brody 2016). Individual packages within cells in a “returnable plastic crate or case… to prevent contact with each other to eliminate surface abrading” (Brody 2016, 516). These cases are relatively bulky and expensive, but they have the lowest marginal cost if returned every time. They can also be used for other beverages that have similar dimensions, so the cost of production for a large

beverage processor is relatively low. Then, cases are “multi-packed, sometimes under compression, sometimes by dropping” to be further protected by corrugated cardboard or plastic shrink wrap (Brody 2016, 515). Cardboard is susceptible to water while plastic shrink film is not.

Paperboard takes constitutes the largest volume of packaging. It loses physical strength when exposed to water or water vapor, so it needs to be combined with other materials (Brody 2016). Virgin paperboard has greater strength per caliper and accepts barrier material for coating much easier while the recycled version is better for printing. Thus, recycled paperboard is often used in secondary packaging, an “outer carton or multi-packer that enables the consumer to carry more than one primary package of a product at a time” (Brody 2016, 507). It does not come in contact with the milk itself. Recycled materials have an unknown history, so “food content safety could be compromised by contaminants” that cannot be “effectively removed in the recycling process” (Brody 2016, 508). It is mostly used in corrugated cardboard cases, with two outer flat layers made from virgin paperboard but the fluted medium comes from recycled paperboard. The “corrugated structure offers vertical and horizontal compression and impact strength to protect the contents. Increasingly, the printing is being improved to permit the cases to be used as retail displays or even as consumer multipacks” (Brody 2016, 508).

For food applications, paperboard is extrusion coated with low-density polyethylene (a plastic) in gable top cartons, which are typically what comes to mind when people picture a milk carton. The layer of plastic “imparts liquid and water vapor resistance as well as broad range heat sealability” (Brody 2016, 522). For UHT milk that can be kept in ambient temperatures, the paperboard is laminated with aluminum foil to prevent moisture from compromising the material rigidity of the paperboard. In its pure form without a plastic cap, gable top cartons are hard to open, reasonable to dispense from, but difficult to reclose properly. Packaging milk into a

paperboard carton requires specialized equipment that snap open the paperboard containers, pour in the milk, and seal the top using pressure and conduction heat.

Milk does not typically come in cans because aluminum can leech out of cans and steel cannot be recycled. Food cans are “coated with chrome/chrome oxide” and “overcoated with plastic (food-grade epoxy) to prevent the metal from corrosion and the product from metallic flavors,” and the plastic in turn prevents them from getting recycled (Brody 2016, 508). Aluminum is not a candidate for food cans because it is not strong enough to withstand bumps and drops.

Glass is the oldest packaging material that is still in use. Even though it has the greatest vertical compressive strength, it is extremely heavy per unit of content, and prone to breakage upon impact, especially after abrasion (Brody 2016, 508). Thus, it is costly to transport long distances and is not often used outside of niche or specialty milk. Even though glass can be recycled, the cost of returning used glass packages to the rapidly decreasing number of glass bottle plants is higher than the benefits. Municipalities are trying to encourage recycling glass through deposits on bottles, but that will probably bring about the decline of glass as a packaging material sooner (Brody 2016, 519).

Popularized in the 1950s, plastic protects the largest volume of contents due to its low density. It comprises about 20 percent of packaging materials (Brody 2016, 508). Plastic comes in various types, with low-density polyethylene (LDPE) and high-density polyethylene (HDPE) as the most popular containers for fluid milk. LDPE is “tough, flexible, easily formed, and lightweight” while functioning as a great water and moisture barrier but a poor oxygen barrier (Brody 2016, 508). Often used in milk pouches, it is also used as a heat extrusion coating on paper, paperboard, aluminum foil, and other plastics. The strength of a milk pouch is engineered

to “resist impact from drops and from internal hydraulic action by content movement,” so it remains intact during transportation. The filled pouch is then placed into a plastic pitcher, and the contents of the pouch can be dispensed from the plastic pitches without making a mess. These pouches also have the lowest carbon footprint because they contribute less volume to landfills (Sun et al. 2021).

High-density polyethylene (HDPE) is a plastic that is semi-rigid, translucent, and easily formable. It has similar properties to LDPE, except that it's rigid. It is the most popular, as it has the lowest weight per unit volume of fluid contents of “any packaging structure[4] that can be opened, reclosed, and comfortably dispensed” (Brody 2016, 522). These jugs can be produced in-house, “blow molded off the line in the dairy’s back room,” and they can be filled at a rate upwards of 100 bottles a minute (Brody 2016, 522). Other forms of plastic such as polyester, polypropylene, and polystyrene are used for other dairy products such as yogurt and ice cream, but they almost never contain milk because of its fluid state.

In Canada, gable-top cartons were introduced in 1915, and supplanted glass bottles by the 1950s. HDPE jugs were made in the 1960s to contain larger volumes of milk. Gable-top cartons tend to contain one or two liters (1/4 to ½ gallon) while HDPE jugs come in two- and four-liter variations (1/2 to 1 gallon). Pillow pouches require a separate reusable jug for support is available in most of eastern Canada, other than Newfoundland and Labrador. They gained popularity in the 1970s because of the switch to the metric system (Johnson 2018). Since then, however, pillow pouches have decreased in popularity, and only provinces part of the P5 in Canada have milk in a bag.

[4] Milk pouches do not disqualify because they require a plastic pitcher for ease of use.

All milk packaging is considered solid waste, so they either end up recycled, bioconverted, incinerated, or buried in a landfill. Using biodegradable materials is not a good solution because they take too long to decompose (Brody 2016, 518). Recyclables need to be separated from nonrecyclables, which can be done by households at the source or "separated from mixed refuse at a central processing plant" (Singh et al. 2014, 349). If the households themselves sort their garbage, separate containers are sent to separate facilities that recycle the materials. Households tend to not sort carefully, so central processing is more cost-effective. Typically, garbage gets placed on a conveyor belt, and workers pick up designated components by hand, a time-consuming and costly process (Singh et al. 2014). Machinery can also break open bags and trommel screens separate cans, glass, and other inorganic materials. Magnets further separate ferrous and nonferrous materials, which all have different destinations. Organic material gets separated into components that can be used for paper or refuse-derived fuel (Singh et al. 2014). Over 50 percent of paperboard, 20 percent of glass, and 60 percent of aluminum cans are annually recycled in the US (Brody 2016, 519). Due to the nature of aluminum, it has been commercially recycled for a long time, even before environmental activism (Brody 2016, 519). Post-consumer packaging materials cannot be safely recycled into food packaging again because of their unknown history. Recycled material has "increased levels of foreign materials that could interfere with product quality" and less developed quality control (Singh et al. 2014, 348). Government intervention that reduces the quality required for food packaging could increase the economic viability of recycling but also harm consumers when parts of packaging leech into the food.

Bioconversion is another option for solid waste disposal: fiber from paper can be converted into protein for livestock and solid wastes can be fermented into ethanol (Drobny et al.

1971; Wilson 1985; Singh et al. 2014; Saha 2003). Since ethanol is relatively cheap, the cost of making ethanol from solid waste is higher than the cost of ethanol itself (Yaashikaa et al. 2020). Incineration used to be a popular option for solid waste disposal in the 1930s and 1940s, but they were a major contributor to air pollution. Today, the cost of running an incinerator is extremely high due to air pollution controls, costing as much as 1.2 billion USD to build an incinerator that can process 1 million tonnes of waste each year (GAIA 2021). Sanitary landfilling is the most common and cost-effective method of solid waste disposal (Singh et al. 2014). Solid wastes get compacted in layers, and each layer is covered with compacted soil at the end of each day's operation. Picking a landfill site is the most expensive part of the process—in other words, the fixed cost of sanitary landfilling is high while the marginal cost is low.

Since most solid waste ends up in a landfill, dairy packaging should aim to reduce its carbon footprint. Pillow pouches require the least energy to produce, at less than half that of a gallon HDPE jug, the next lowest embodied energy required for milk packaging (Fry 2010). Additionally, they also produce the least greenhouse gas emissions, around half of what a half-gallon carton produces and less than one-third that of a gallon HDPE jug (Gerber et al. 2010; Sun et al. 2021). Net water consumption is also the lowest for pillow pouches. If all three materials end up in a landfill or getting incinerated, pillow pouches take up the least volume.

Since Canada claims that it wants to reduce its carbon footprint, its dairy subsidization policies inadvertently increase the carbon footprint of each unit of packaging. It remains to be determined whether the reduction in embodied energy of each unit of packaging is larger than the redundant costs of transportation. Data on the average distance milk covers from a dairy farm to the grocery store, broken out by province and type of milk proves scarce. Pillow pouches exist in Canadian provinces that have smaller dairy farms and more farms per capita of population,

which implies that pillow pouches hit diseconomies of scale earlier than cartons or HDPE jugs, even though the latter can be produced in-house as well. Consumption per capita of fluid milk has also decreased in the last two decades, as cheese and butter products have become cheaper relative to milk due to industrial milk subsidies. Subsidization of industrial milk lowers the cost of producing cheese and butter, both of which have large economies of scale in production. They require a constant stream of milk to be available: it takes 20 to 25 liters of milk to produce one kilogram of butter and 10 liters of milk for one kilogram of cheese. Hence, dairy subsidies lower the relative cost of cheese and butter production, which come with large economies of scale.

5. Conclusion

Dairy subsidies raised the relative rate of return on industrial milk in Canada, which shifted producers into the cheese and butter market, favoring large operations. Price ceilings on the price of milk production quota curtail the rate of expansion for dairy farms, decreasing the average distance milk travels from a farm to a store. Pillow pouches become a viable form of packaging, as they have higher costs of long-distance shipping relative to cartons and jugs. Since most solid waste ends up in a landfill, plastic pouches have the smallest carbon footprint of all three packaging choices. With dairy subsidies, fluid milk is not as attractive to producers as industrial milk, which increases the average distance milk has to be transported between farms, processors, and grocery stores.

In the last couple of decades, environmental activists have gained significant traction, and consumers today tend to say that they care about recycling and the environment. Paperboard can be recycled, but incorporating recycled materials into food containers could increase the rate of contamination due to the unknown history of the material. Additionally, recycled paperboard

does not have the same toughness as its virgin counterpart. The Canadian government wants to ban single-use plastics, but their dairy policies increase emissions created by milk packaging.

In future research, one could see if there is a correlation between the time when the first generation of farmers retired and an increase in quota prices, and a decrease in the number of farms. Nearly half of all dairy producers in Canada were older than 50 years old in 2011. New entrants have to pay for quota, and the quota from retiring farms is sold to potential entrants as well as existing dairy farms. Another avenue of further research could be Newfoundland and Labrador. Milk does not come in four-liter containers, only one or two. Goat milk comes in a bag, but fluid milk comes in one- or two-liter jugs and cartons. There are only 25 farms and two processors in Newfoundland and Labrador, and producers often ship industrial milk to Maritimes for processing (The Real Dairy Company of Newfoundland 2022). They may or may not have a price ceiling on the quota of milk; if they do, it's a recent development because the average size of dairy farms are the largest in the country, averaging 200 per farm. Additionally, dairy packaging in the United States might be explained similarly. The U.S. Department of Agriculture pays a support price according to the class of milk; dairy farms are relatively large compared to Canada, and milk in a bag does not exist outside the Midwest today.

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