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FAST FASHION: WHY FIRMS INCINERATE DEADSTOCK, AND PUBLIC POLICIES

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Abstract

Fast fashion increases the overall consumption and need for new products each season. With trends rapidly fading away, remaining garments lose their value and occupy precious space in stores. The destruction of unsold inventory contributes to the already significant environmental impact of the fashion industry. This excess stock needs to be managed, but, at the moment, there are little sustainable alternatives to landfills and incineration centers. Fast fashion garments fit the setting of a newsvendor problem as sales forecasts are difficult to make accurately. With loss-averse decision-makers, it is expected for retailers and brands to order larger quantities than the actual realized demand. A lifecycle mindset establishes the relevance of addressing these end-of-life issues by looking into how products are designed, manufactured, and distributed. This work is an overview of a garment's conventional supply chain following commodity flows of cotton and polyester from their raw material stage to worn apparel and highlighting the fashion industry main areas of environmental impact. The globalized nature of the industry creates consumer countries dependent on imports for their fashion consumption and ill-equipped to manage post-consumer textile waste. Reuse and recycling are major strategies for a sustainable transition, but they are strongly limited by the saturation of second-hand markets and the lack of reliable textile waste management practices. Public policies are critical to support solutions along the entire supply chain from processes to garment value recovery. As unsold inventory is expected by firms, there is a need for policymakers to reduce incentives and existing mechanisms behind stock destruction.

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Introduction

Apparel is the third-largest manufacturing industry (Fashion Revolution, Sept. 2018). Our linear way of producing, using, and disposing of garments generates significant environmental and social impacts that require a systemic change in order to transition towards a sustainable industry (Fletcher, 2014; Environmental Audit Committee, 2019). Social impact revolves around working conditions and fair wages, with various forms of forced labor present in all production phases. Similarly, environmental impacts along the supply chain are mostly a contribution to climate change through greenhouse gas (GHG) emissions and an endangerment of ecosystems quality due to a heavy water footprint, land use, intensive use of chemicals, and plastic pollution from waste generation. The destruction of unsold inventory intensifies the already heavily impactful apparel industry.

It was infamously reported in 2018 that the luxury brand Burberry burned high quantities of inventory of accessories and clothing to preserve their elite image with the defense of recovering energy (Environmental Audit Committee, 2019). This scandal and the effects of fast fashion on the United Kingdom led to a report with recommendations from the UK Parliament's Environmental Audit Committee on the issues of the fashion industry. This example is relevant for the Canadian context as our industry is similarly based on fast consumption and imports.

The fast fashion phenomenon is far from new, and it has shaped businesses in the industry by making them adopt models that required a fast and flexible supply chain. Apparel products characterized as fast fashion have a high fashion content and are influenced by rapid trend cycles (Mehrjoo and Pasek, 2014). Shifts in culture and popularity influence consumers' demand, which creates new fashion trends and a desire for its newness (Barnes and Lea-Greenwood, 2006).

There is a "symbiotic relationship between fashion firms and consumers" (Fletcher, 2014) that blurs the burden of responsibility for the intense environmental impact of garments. Thanks to fast fashion, more people have access to fashionable products for an affordable price, and people's lifestyles have increased clothing consumption since the 1980s (Bhardwaj and Fairhurst, 2010). This improves welfare as it fulfills the consumers' need for novelty more easily. The downside of fast fashion is that garments are more quickly discarded and replaced, which creates

a waste generation problem at the same time as new garments are needed. The supply chain's agility or responsiveness became essential with the dominance of fast fashion products, but it "increases unsold commodities, return rates, packaging materials and waste" (Jia et al., 2020) which intensifies the overall impact. Furthermore, clothing and accessories are subject to a short life cycle, impulsive buying from customers, high demand uncertainty and obstacles to forecasting (Christopher et al., 2004). It increases the market volatility as well because of lower quality products (Environmental Audit Committee, 2019). At the end of a selling season and when the trend passes, garments have a significantly smaller value. This devaluation contributes to the problematic behavior of destroying unsold inventory (Environmental Audit Committee, 2019; Napier and Sanguineti, 2018). The same goes for returns that are not integrated into a reverse logistics channel capable of keeping the products value. It happens in luxury market segments but also in fast fashion.

The industry leaders are well-positioned compared to the 40% of firms that have done little to nothing in terms of sustainable initiatives (Global Fashion Agenda and Boston Consulting Group, 2017). Thanks to pressure from awareness campaigns and to ample resources, they have been able to adopt more environmentally friendly and ethical strategies than other businesses. Also, the communications on the implemented strategies are setting up the groundwork for a transition (Macchion et al. 2018). However, small and medium businesses form most of the industry's firms. Those find themselves incentivized to optimize profits and minimize costs regardless of the critical environmental and social consequences.

Supply chains in the industry have been adapted by stakeholders to ensure the most significant market share for brands, which makes the industry market driven. Like other industries, the apparel industry must deal with the integration of its stakeholders to increase benefits from collaboration (Bruce et al. 2004). Particularly, brands and retailers have taken further control of logistics and operations (O'Marah, 2001; Bruce et al. 2004; Macchion et al. 2018). It can be argued that it transformed the competition between companies into competition between supply chains (O'Marah, 2001). Paradoxically, parts of the supply chain like yarn spinning, fabric production and garment manufacturing remain highly fragmented.

Retailers and brands would turn to incineration and landfills as strategies of disposal for their unsold products because it can be economically more favorable to them. However, landfills or

incineration centers are the lowest strategies in the waste disposal hierarchy (Kumar and Malegeant, 2006; Jacometti, 2019). Instead, retailer and brands should invest on reverse logistics channels capable of preserving at least part of the product's value. Secondhand markets are the main closed-loop channel for garments in Canada, but textile-to-textile recycling options are in small scale or still in early development stage. Governments are also reinforcing their commitments to the need for regulations designed to inhibit the apparel industry's negative impact by discouraging these destructive strategies. Considering all this, how can public policies influence the environmental and social impact of the apparel industry? An analysis can be based on a newsvendor problem to determine how regulations such as taxes or an extended producer responsibility legislature can better the apparel industry's sustainability.

Indeed, a fast fashion product has characteristics that make it appropriate for the setting of a newsvendor problem as it has a short lifecycle and demand uncertainty. Retailers base their orders on a projection of how sales performed previously for similar products during the same selling seasons (Environmental Audit Committee, 2019). When retailer's risk preference is to avoid losses, they find themselves ordering an excessive quantity of a product.

With the pandemic, the harmful impacts worsened as orders were cancelled early on (Fashion Revolution, April 2020), and the economic cost of halting the worldwide industry was put on the shoulders of the manufacturing workers (Law, 2020).

Considering the increased consumption due to fast fashion and the significant problem of stock destruction at the end of a season. Stakeholders and governments could play a significant role to reduce those impacts, having the decision-making and law-making power. This communication will first present an overview of the state of the industry, and then will attempt to outline the reasons and environmental impacts for stockpile destruction. A portrait of the stakeholders will follow. Then, a flowchart highlighting the life cycle of the fibers, what is known and what is missing will be presented. Finally, some existing policies will be put forward.

Fast fashion

Cachon and Swinney (2011) define a fast fashion brand as one combining high fashion products with fast lead times. A positive take on fast fashion is that it brings new, and trendy looks to

consumers unable to afford luxury items. Brands and retailers strive to fulfill this consumers' desire for newness at an affordable price and in time for the rapid change of trends. In turn, it impedes retailers from forecasting the demand for new products, which compromises the accuracy of quantities ordered to manufacturers. Hence, fast fashion brands and retailers have established supply chains that are fast and agile enough to meet consumer's expectations. Paradoxically, retailers also require a more standardized supply chain to improve product variety by offering basic articles in their apparel groups (Şen, 2008; Mehrjoo and Pasek, 2014). Such variety in apparel articles and the capability to develop products quickly and bring them to market increases a firm's market share and competitiveness (Mehrjoo and Pasek, 2014). It increases consumption and heightens the apparel industry's impact on social and environmental dimensions.

Additionally, fast fashion trends follow seasonality, going up to five seasons per year for some retailers (Şen, 2008). Each seasonal collection has multiple apparel articles resulting in retailers having to introduce new products on store floors every week or two weeks (Şen, 2008). Once the trend fades, a fast fashion garment loses value because its high fashion content becomes outdated. Advertisement and social media contribute to this overconsumption by "selling a message of satisfaction after purchase" (Binet et al., 2019). With the fast fashion segment leading growth, consumers want to renew their wardrobe and stay on trend. They spent up to 60% more on clothing between 2000 and 2014, while keeping the garments for only half the time (Remy et al., 2016). With Canada being a top 10 importer (ITC, 2020), it can be expected that its population displays a similar rate of consumption.

McNeil and Moore (2015) focus on what influences the compromise that customers must make between their sustainability awareness and a fashion consumption that fulfills their need for identity construction. The authors highlight that fast fashion consumers have a frequent purchase rate, are motivated by enhancing their image and try to fit in with peers. There is hope for sustainable purchases, and customers care for a brand's responsibility, but it is yet a concern to be seen in real consumer behavior because of prices (McNeil and Moore, 2015). This rapid obsolescence is one of the reasons apparel has a short lifecycle, but it is also caused by low quality products resulting from the focus on speed in the supply chain compromising tests (Environmental Audit Committee, 2019).

Furthermore, retail stores find themselves intertwined with customers exhibiting various behavioral patterns. When determining their inventory and pricing policy, retailers have to consider strategic consumers' purchase decisions. Cachon and Swinney (2009) modelized the equilibrium between the retailer's interest and strategic consumers, expecting prices to go down during the selling season. Indeed, markdown prices are part of dynamic price policies and retailers have far more strong incentives to choose this strategy than a static fixed price (Cachon and Swinney, 2009).

In the last decade, retailers have consolidated around larger brands and started private labels (Şen, 2008). Because retailers are the closest to consumers and their demand, this gives them an advantage in designing trendy products, which become enhanced in their value (Cachon and Swinney, 2011). Additionally, retailers started controlling manufactures' production in a vertical integration way, which reduces their costs and the time needed. These two advantages are particularly present in fast fashion retailers and are heightened in the presence of highly strategic consumers as both reduce incentives to delay a purchase (Cachon and Swinney, 2011). Hence, successful fast fashion retailers would invest resources into ensuring the speed of their supply chain and that their products have a high fashion content. However, following the latest trends this way and with such speed exacerbates the obsolescence of these garments.

In 2020, the retail part of Canada's fashion industry's worth was close to 2 billion CAD (Statistics Canada, n.d.), whereas the whole clothing product manufacturing was 1,2 billion CAD (Statistics Canada, n.d.). It reflects well how retailers have become major decision-makers in countries where the consumption of apparel is dependent on import.

Unsold inventory destruction

Stochastic demand and risk preference

With the typically short lifecycle and demand uncertainty, inventory management for fast fashion retailers exemplifies the newsvendor problem, which forces a firm to make a decision on quantity and prices without precise knowledge of demand for the product. The uncertainty in the demand forecast provoked by fast trend cycles and seasonality can be represented by a stochastic model (Qin et al., 2011). Hence, in the fast fashion context, the consumer demand becomes prospective. The newsvendor problem assumes no restrictions and no lead time for suppliers as

well as a risk-neutral buyer (Qin et al., 2011). It is not the case for the apparel industry, where orders must be put months in advance and buyers are not necessarily risk-neutral. Indeed, brands and retailers have variable risk preferences that need to be considered. The stochastic demand and the risk preference from decision-makers ordering quantities affect the optimization of the production. Adhikari et al. (2019) revealed how the risk preference of retailers influences a cotton garment's overall supply chain performance.

If a retailer is considered loss-averse, their preference will be to avoid losing revenue over gaining the same amount. In this case, they will order less than the future demand in fear of having spent too much. However, ordering less could lead to missing sales and trying to avoid that scenario refers to a stockout-averse preference (Schweitzer and Cachon, 2000). In this scenario, fearing the loss of sales and customer loyalty, retailers, and brands order larger quantities than the expected demand during the selling season (Schweitzer and Cachon, 2000). For a fast fashion garment, this safety inventory works as a buffer, ensuring no customer is dissatisfied because they missed out on the newest trendy garment. After the selling season, however, the unsold inventory has very little salvage value because of the passing trend's obsolescence. These insights help understand the problems of generating unsold inventory that ultimately entails storage costs or disposal costs.

An important addition to the question of how to dispose of unsold inventory is dealing with returned articles. Reverse logistics enables channels to reintroduce these returned products for reselling or direct them for reuse in secondhand markets. However, the efforts to adopt such strategies are rarely given by decision-makers (Paras et al., 2019). Like unsold inventory, returns also have little value after the selling season and are sent to landfills or incinerated. It is also the case for returns from online shopping (Cullinane and Cullinane, 2021). Fast fashion has the effect of increasing the quantities of garments in these situations.

Incentives

Retailers and brands in different market segments of the fashion industry have varied kinds of incentives to destroy unsold inventory. Sought outcomes range from simply freeing stock space to protecting a brand's image or trying to benefit from tax credits given for energy recovery through incineration (Napier and Sanguineti, 2018).

For a fast fashion firm, Napier and Sanguineti (2018) identify a cause of stock destruction as excess production related to miscalculations in ordered quantities. However, it is misguided to link the devaluation of a product at the end of its selling season and its destruction when disposal strategies are already planned and established. Furthermore, fast fashion brands and retailers have established supply chains that allow fast speed to market and inventory resupply. Two advantages that minimize errors due to uncertainties induced by rapid trends, which justifies the investments made on responsive supply chains. Hence, it can be argued that the ordered quantities are optimally calculated to exceed expected sales. In a loss-averse scenario, it is the anticipated strategy that a retailer would adopt to maximize their profits (Schweitzer and Cachon, 2000).

Interestingly, for luxury brands, stock destruction is an issue of brand image protection (Kumar and Malegeant, 2006; Napier and Sanguineti, 2018). Specifically, they try to avoid situations where their products are sold under large discounts as it compromises the brand's elite image. Destroying excess stock avoids this outcome and contributes to ensuring product scarcity (Napier and Sanguineti, 2018).

In general, for players from all market segments, the costs of implementing and maintaining strategies remain an important barrier to systemic change (Kumar and Malegeant, 2006). Particularly, there is a need for reverse logistics, which are operations that allow brands and retailers to retrieve worn garments from consumers once the later seek to dispose of it. To incentivize firms to make sustainable commitments and take tangible actions, there is a critical need for access and accountability to their own end-of-life products.

Environmental impact

The textile and apparel industry has an environmental impact that contributes heavily to GHG emissions, water scarcity and pollution, and waste generation (Sandin and Peters, 2018; Roos et al., 2016: Niinimäki et al., 2020). Fast fashion's intrinsic characteristics exacerbate these impacts by increasing the rate of production, consumption, and disposal, especially when retailers and brands destroy their unsold inventory. This becomes even more important considering the expected increase in purchasing power of emerging economies (Remy et al., 2016). The "race to the bottom" for minimizing costs by localizing operations where working conditions and

environmental regulations are weaker (Rivoli, 2014) also contributes to the impact of operations along the supply chain.

In 2018, the consulting firm Quantis contributed to the understanding of the industry's global impact with their report "Measuring Fashion: Environmental Impact of the Global Apparel and Footwear Industries Study". Their lifecycle assessment of a garment highlights which phases of production are the most impactful and for which damage category from the IMPACT 2002+ method. They determined that the primary contributors are the energy sources based on fossil fuels that fabric manufacturers use (Quantis, 2018). The steps preceding a garment's confection are the phases requiring the most of these resources. Hence, fiber production, yarn spinning, fabric manufacturing, dyeing, and finishing treatments encompass nearly 80% of a garment's impact. Types of fibers add nuance to the impact of those production phases as they require different processes. For damages related to climate change, synthetic fibers intensify GHG emissions as, with over half the world's market shares (Textile Exchange, 2020), they are the most used materials, with polyester fabric dominating the market. Its manufacturing is concentrated in Asia, particularly in China, and by petrochemical companies that produce the PET needed for polyester (Grand View Research, Feb. 2020). The findings of Quantis are aligned with the "Environmental assessment of Swedish fashion consumption" done by Mistra Future Fashion that highlights the impact taking place during production phases as far more significant than use and disposal (Roos et al. 2016). Additionally, the transport of materials and components worldwide is another leading contributor to GHG emissions because of the globalized and fragmented nature of the industry (Rivoli, 2014).

Another important damage category relevant to the industry is the degradation of the ecosystem's quality. Dyeing and finishing treatments for fabrics are chemical-intensive processes, but needed for garments' aesthetics and functionality criteria. Fabrics have finishing treatments for specific attributes (e.g. softness, water repellant, flame retardant, etc.) and color dyes change rapidly depending on trends. Furthermore, pesticides are posing a significant danger for biodiversity in regions with intensive cotton cultivation (Plant Production and Protection Division, 2015). Cotton also has a particularly strong impact on ecosystems quality, as it requires vast stretches of land, amount of water and chemical products to produce the high volumes demanded by the textile industry.

The Ellen Macarthur Foundation published, in 2017, an essential report about sustainability in the fashion industry highlighting how its linearity generates important amounts of waste annually. One of the most striking conclusions of "A New Textiles Economy: Redesigning fashion's future" is how textiles' material flow has only 2% of input material that comes from recycled products originating in other industries and so few channels to recycle end-of-life garments into new pieces of clothing. Instead, while textile-to-textile recycling represents 1% of disposed textiles, 12% of used garments are downcycled in other industries, and 73% end up in landfills or incinerated (Ellen MacArthur Foundation, 2017). The rest of end-of-life textiles are lost either during production, collection or through washing. It becomes worrisome when waste hierarchy is taken into consideration. Waste prevention and treatments that preserve utility, or material value at the very least, are recommended over final disposal methods (Jacometti, 2019).

Apparel supply chain

View of Interests

Omnipresent, the apparel industry today is a good example of a globalized industry. Picking up steam during the Industrial Revolution, production started delocalizing to where costs were reduced, and profits maximized. Since then, this reality has continued to happen (Rivoli, 2014; Bruce et al., 2004), resulting in many stakeholders worldwide navigating diverse interests and barriers.

Fast fashion transformed the conventional supply chain into a business model that can answer challenges related to a product with a short lifecycle and demand uncertainty. Barnes and Lea-Greenwood (2006) summarize that a quick response supply chain answers the needs for fast fashion by allowing the supply chain to identify trends and adapt to them thanks to the flexibility given by a fast speed to market. However, they show that fast fashion became a concept on its own as it expands further than the supply chain characteristics and "is a completely consumer-driven process" (Barnes and Lea-Greenwood, 2006). Its responsiveness leads to a virtual vertical integration, where the decision-makers of each stage are coordinated if not owned by the same corporation (Barnes and Lea-Greenwood, 2006).

Brands were conventionally the main decision-makers regarding production since they design, put orders in with manufacturers and decide on pricing strategy. It is still the case for the luxury

market segment. Considering the newsvendor problem, quantities ordered by brands are prospective because the demand for the new product is stochastic. On their side, garment manufacturers and textile producers try their best to prepare for the brands' order each season. The result is a realized production quantity based on a future order that is already a projection of sales (Environmental Audit Committee, 2019). Even with the agility of a fast fashion supply chain, there are important uncertainties for the demand of each apparel collection. It becomes even more relevant as those have increased in numbers.

Nonetheless, a shift took place and retailers became the industry's new primary decision-makers when private labels from stores increased in numbers during the early 2000's (Barnes and Lea-Greenwood, 2006). To adapt products' design accordingly and on time, decision-makers need to access information on fashion trends (Cachon and Swinney, 2011). Retail buyers have the most advantageous position as they are closer to the data and feedback from consumers' purchase behaviors. This closeness with the demand reduces uncertainties for retailers. Hence, just like brands, retailers could offer private labels with high fashion content that meets trends and demands of consumers, but cheaper than a luxury market price. In addition to trends, there is time pressure due to the competitive environment, increasingly demanding customers and strategic behavior. Today's industry highly values the fastest lead times, while keeping low costs is a challenge that motivates new supply chain structures. More than quick response supply chains that adopt lean and agile strategies, it can be argued that the fashion industry developed its own distinct concept due to the market characteristics (Bhardwaj and Fairhurst, 2010; Bruce et al., 2004).

However, fast lead times of a fast fashion supply chain puts pressure on quality control processes (Environmental Audit Committee, 2019), which results in a low-quality product. The other part of the competition for low-quality garments is their low-price, which appeals to a broader range of consumers. Nowadays, with the digitalization of commerce, being competitive based on pricing is even more vital. The factor of fast lead times would also indicate that order sizes are optimized due to the retailer's closeness with the consumer demand, which should minimize waste along the supply chain. It is an argument that is made in favor of a fast fashion business model with short lead times (Cachon and Swinney, 2011).

Still, trendier garments quickly reach an end of useful life and become post-consumer waste, especially in the context of fast fashion. Due to the linearity of fast fashion products' life cycle, waste prevention during production does not reduce the end-of-life waste related to a rapid consumption rate. Hence, it becomes crucial to look at how garments are manufactured, consumed and at what are post-consumer waste treatments alternative to landfills and incineration centers. Which are the primary methods of disposing of worn garments.

Linear supply chain

The stakeholders in the apparel industry have different interests, but they would all profit from further collaborating in reducing waste and closing the loop on material flows. A start has been seen since the 2000s, when the industry saw the adoption of lean, agile and just-in-time strategies to improve speed to market and the flexibility of orders (Bruce et al., 2004). However, the supply chain remains vastly linear, and it is relevant to understand how this conventional linear model works.

The apparel industry is significantly globalized, with commodities flowing between countries worldwide (Rivoli, 2014). Tracking where the materials originate in the supply chain and where they are sent from one production stage to another is a useful tool to understand and situate garments' lifecycle. From a take-make-use supply chain, the sequence of production and distribution stages starts with raw material extraction, fiber production, fabric production, garment manufacturing, and ends with the retailer (Rieple and Singh, 2010). Then, the use phase and the end-of-life treatments were added to consider a garment's environmental impact for its whole lifecycle. The Harmonized System Classification (HS) was helpful to categorize commodities (UN Trade Statistics, 2017) as well as to determine the relevant commodities to follow. The International Trade Center (ITC) website (www.trademap.org) was also useful to determine which countries are the top exporters and importers. The ITC mainly uses data from the UN Comtrade database and Statistics Canada for Canadian imports and exports. The next step was to verify data availability. For a reliable portrait of the commodities flow, the most recent year suitable for reference is 2018. Hence, it was chosen as the reference year. The goal was to determine the main countries involved in order to confirm initial assumptions and identifying new leads for investigation.

From fiber to garment

Fibers

According to Textile Exchange, a nonprofit organization that coordinates the industry to promote preferred materials, synthetic fibers dominate the global market, followed by natural (cotton) and then man-made cellulosic fibers. For the year 2018, polyester alone represented 51,5% of global market shares, whereas cotton was 24,4%, and artificial fibers like man-made cellulosic fibers were 6,2% (Textile Exchange, 2019). The following year, their share of the global market increased slightly (Textile Exchange, 2020). Figure 1 illustrates the distribution of these main fibers in the global market.

Other types of materials used for garments, like silk, wool, and down were not considered because each was less than 1% of the market share. Those materials and leather are considered noble materials. As such, they are more expensive and mostly used for high-end or luxury apparel. For an analysis of fast fashion garments, it is less relevant to track those materials' flow. Hence, only the three primary fibers (synthetic, natural, artificial) are initially considered. Respectively, polyester, cotton and viscose dominate each of the top fiber categories. Understanding the main fibers is relevant as their blend into fabrics is one of the main technical obstacles to textile recycling.

Polyester, made from polyethylene terephthalate (PET), is the main synthetic fiber and represents by itself 51,5% of 2018's global fiber market (Textile Exchange, 2019). PET is spun into threads by different processes (e.g. melt spinning) before being sold as yarns. Because of polymers needed for polyester, petrochemical companies are well positioned to produce the PET made into polyester yarns. It is a form of vertical integration, where manufacturers of raw materials are also the ones producing fibers and fabrics. Companies adopting this strategy are concentrated in Asia, particularly China (Grand View Research, 2020).

Additionally, polyester has the potential to play a role in the industry's transition toward a circular economy. Recycled PET's (rPET) part of the input of raw materials for polyester increases each year and creates opportunities for an economically viable channel for recycled PET. Indeed, last-mile plastic collection projects reduce quantities of plastic bottles that reach oceans. The development and affordability of business models incorporating recycled fibers also lead to positive impacts for those companies. Still, polyester is made of fossil resources, and 75%

of the raw material used is still virgin PET (Textile Exchange, 2019), which increases its GHG emissions and impact on nonrenewable resources. Closing the loop on end-ot-life PET with rPET is a way of reducing the pressure on the demand for fossil resources.

Man-made cellulosic fibers are manufactured from organic materials through processes of transforming cellulose into artificial fibers. Like synthetic fibers, it is a man-made fiber, however artificial fibers are made from organic materials. Hence, it has a powerful circularity potential as it can be made from other industries' waste like woodshedding. Lenzing is a good example of the sustainability issues that artificial fibers can address as they developed a fiber manufactured partly with waste cotton (Fontell and Heikkilä, 2017). However, viscose still dominates artificial fibers by representing 79% of man-made cellulosic fibers' share on the global fiber market (Textile Exchange, 2020) and it has its own issues. Unfortunately, as viscose is mostly made from wood, and some can be made of FSC-certified wood, this material is often linked with deforestation and exploitation of protected rainforest. As with the case of synthetic fibers, artificial fibers are also predominantly manufactured and imported by Asian countries.

Cotton has important characteristics that need addressing. Its cultivation occurs worldwide in warm climates, with China, USA and India being the largest producers of raw cotton (ICAC, 2020). However, Figure 1 shows that the USA is by far the primary exporter of raw cotton, and China is the leading importer. It indicates two interesting realizations. First, as cotton crops are cultivated globally, it is also produced with very different levels of technology and institutional incentives. The USA does not have a strong textile manufacturing industry as it once had, but Texas is still a cotton production powerhouse (Rivoli, 2014). Hence, its cotton is exported to international markets where it competes with cotton from other exporters like Australia, Brazil and West African countries. Secondly, China's production is directed towards their own domestic market, and it still does not fulfill the demand for raw cotton. From this raw material form, it needs to be cleaned through ginning before being spun into yarns. The findings match the known assumption that the textile industry is still a leading economic driver in China even if the sector is changing (Rivoli, 2014).

Fabrics

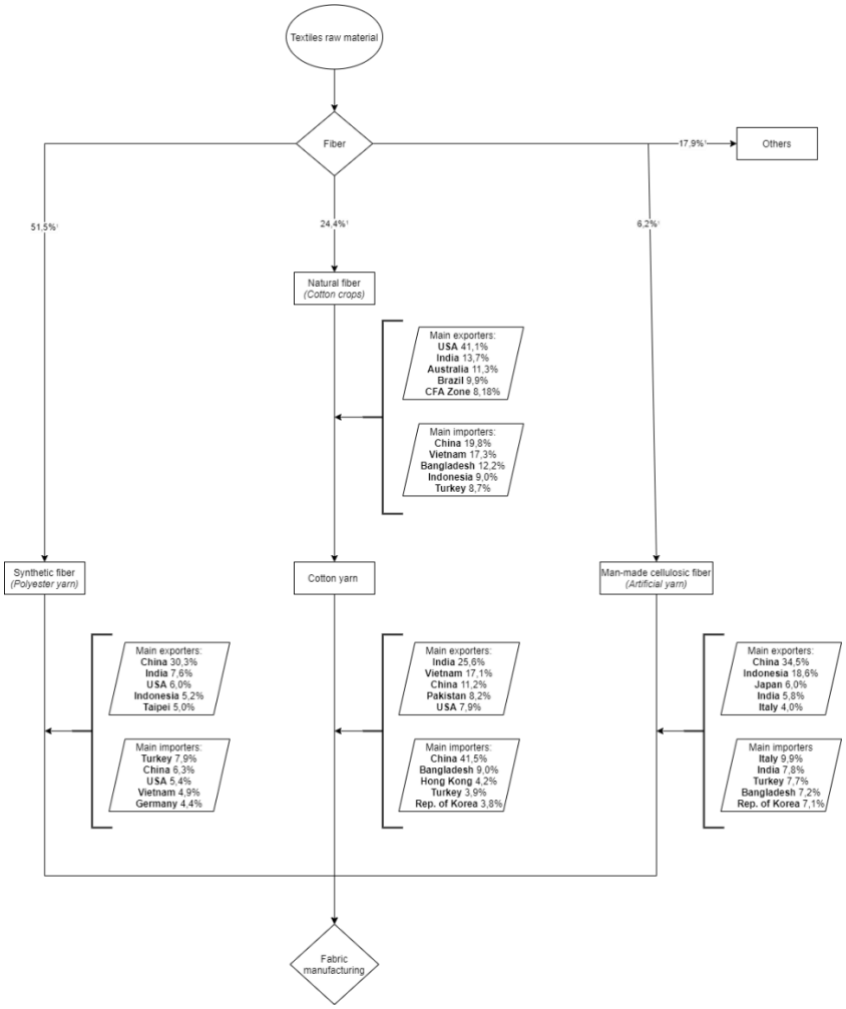
Once raw materials and fibers are transformed into threads, it is spun into yarns to be sold as an intermediate product and transformed. These processes are crucial as it conditions the threads to work with the machines that weave or knit them into fabrics.

It is uncommon for fabric rolls to be made of purely one fiber type, as it is often blended with other materials to achieve functional criteria. Polyester, mostly, is often mixed with cotton or viscose to allow the textile to become more breathable. Whereas cotton is often mixed with elastane to add flexibility to the garment. The result is a fabrics market mostly composed of blended textiles.

Dyeing and finishing treatments can take place in different stages of production depending on the desired result. Techniques vary as some producers might dye fibers while spinning the threads into yarns, while others do it once the fabric is already woven or knit. The substances, such as hazardous chemicals, are essential for the end result and, thus, the value of the apparel and its performance during use. However, other than their impact on ecosystems and workers' health, there is also a consideration for how these substances can affect and compromise recycling processes.

Figure 1 shows how the leading exporters of yarns are also the Asian countries that either had a domestic production or imported the raw materials. It is interesting to highlight that cotton continues to flow towards China. Indeed, the fabrics market is very fragmented but remains regionally concentrated in Asia and particularly in China and India due to the "low labor cost and predominant apparel consumption" (Grand View Research, 2020).

Figure 1. From fibers to the fabric.

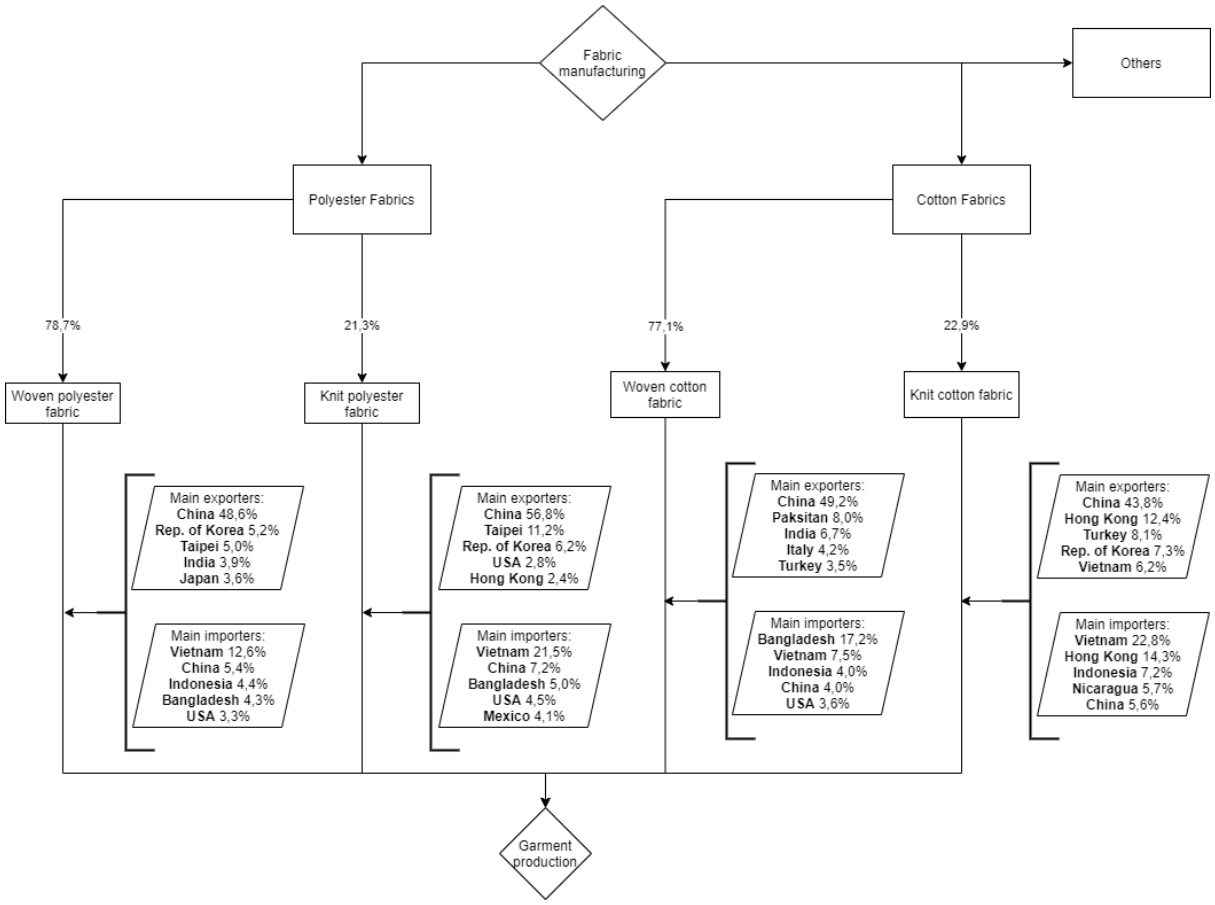


Note: Trade flow data from International Trade Center, Trade Map - Canada, retrieved online in August 2020

Source: 1. Textile Exchange, 2019

To achieve fabrics with various looks and functionalities, different types of fibers can be blended. Often, cotton or polyester are mixed with small quantities of man-made cellulosic fibers to add an aspect of elasticity and comfort to the apparel. The HS Classification allows for tracking blends, but it still refers to the quantity of cotton or polyester in the yarn, fabric, or garment. Viscose and other fibers that are added for performance criteria become less trackable. Indeed, either with cotton or polyester at 85% and more, the codes' categories remain in those same two main types of fibers in the market. Figure 2 further explores them by looking at woven and knit processes. It is interesting to note that the global market value of woven cotton and polyester fabrics is thrice higher than the knitted ones.

Figure 2. From woven and knit fabrics to garment manufacturing.



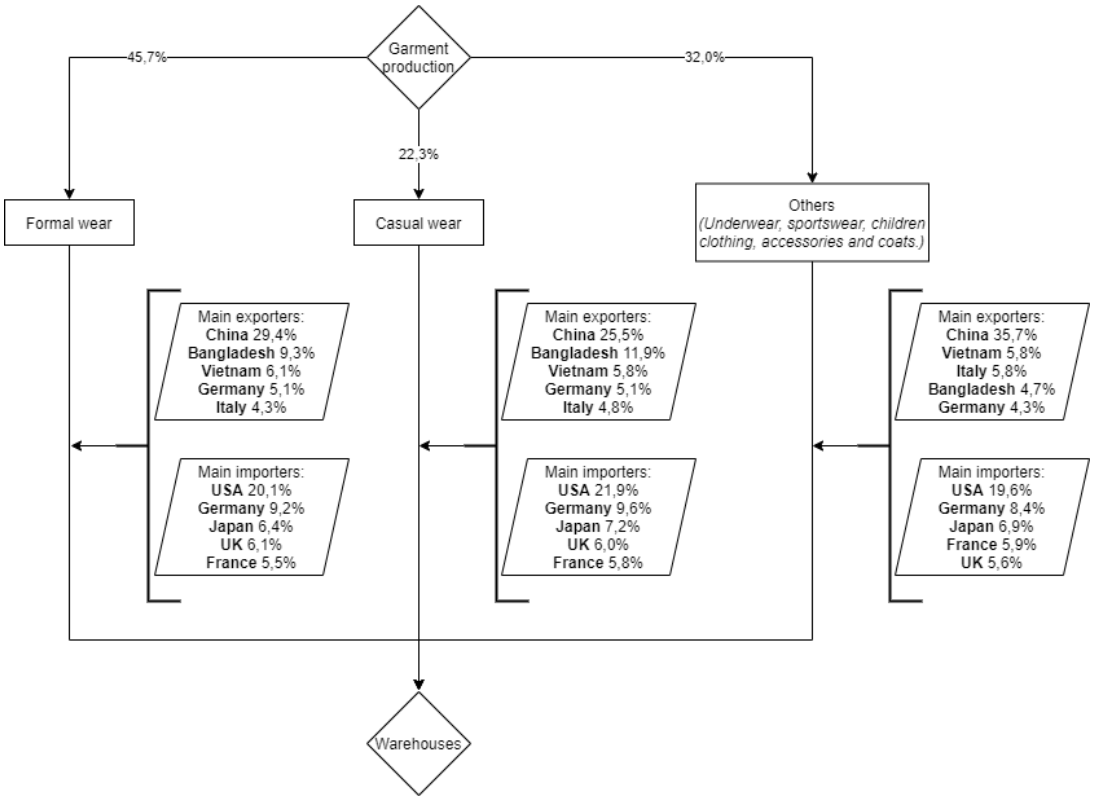
Note: Trade flow data from International Trade Center, Trade Map - Canada, retrieved online in August 2020

Garments

Exported Garments cross similar borders to the commodity flow of fabrics. Indeed, as Vietnam, Bangladesh and China import fabrics, these countries are the top exporters of garments in the global market. Figure 3 shows which countries represent the largest consumer market. As expected, garments originate in Asia and flow towards the USA, United Kingdom and Germany.

While yarn manufacturing and textile manufacturing are fragmented markets with a multitude of agents, revenue from clothing manufacturing is concentrated in a few multinational companies worldwide.

Figure 3. From garment manufacturing to stores.



Note: Trade flow data from International Trade Center, Trade Map - Canada, retrieved online in August 2020

End-of-life

It was useful to track commodity flows to observe the origins and destinations of materials and their transformation to grasp the globalized nature of the industry. However, it becomes flawed when trying to analyze where the end-of-life treatment for post-consumer garments that became waste mostly takes place. For apparel, HS codes are limited to track worn garments destined to second-hand markets when identified as such, but it becomes useless for other disposal methods. End-of-life disposal alternatives like landfills and incineration are mostly local from curbside collection or regional operations including industrial waste. However, municipalities are rarely equipped to collect and sort textile waste appropriately. Recycling processes for textiles are still under development (Fontell and Heikkilä, 2017), and the volume of waste directed to such alternatives is limited (Ellen MacArthur Foundation, 2017). Hence, we lose track of the volume of waste when using the commodities flow because worn garments do not cross international borders to be disposed of in these ways.

Reuse is the most present alternative to avoid these final disposal methods. Worn clothing sent to secondhand markets is an interesting but limited channel for retailers and brands looking for ways to dispose of unsold inventory and returns.

Indeed, second-hand market notable exception to the tracking flaw because donated garments can be tracked as they are exported. Reuse would be the preferred disposal type over other methods as it preserves the garment's function, material and energy used for production. From the main countries importing garments in Figure 3, the United States, United Kingdom and Germany are also the leading exporters of worn clothing in Figure 4.

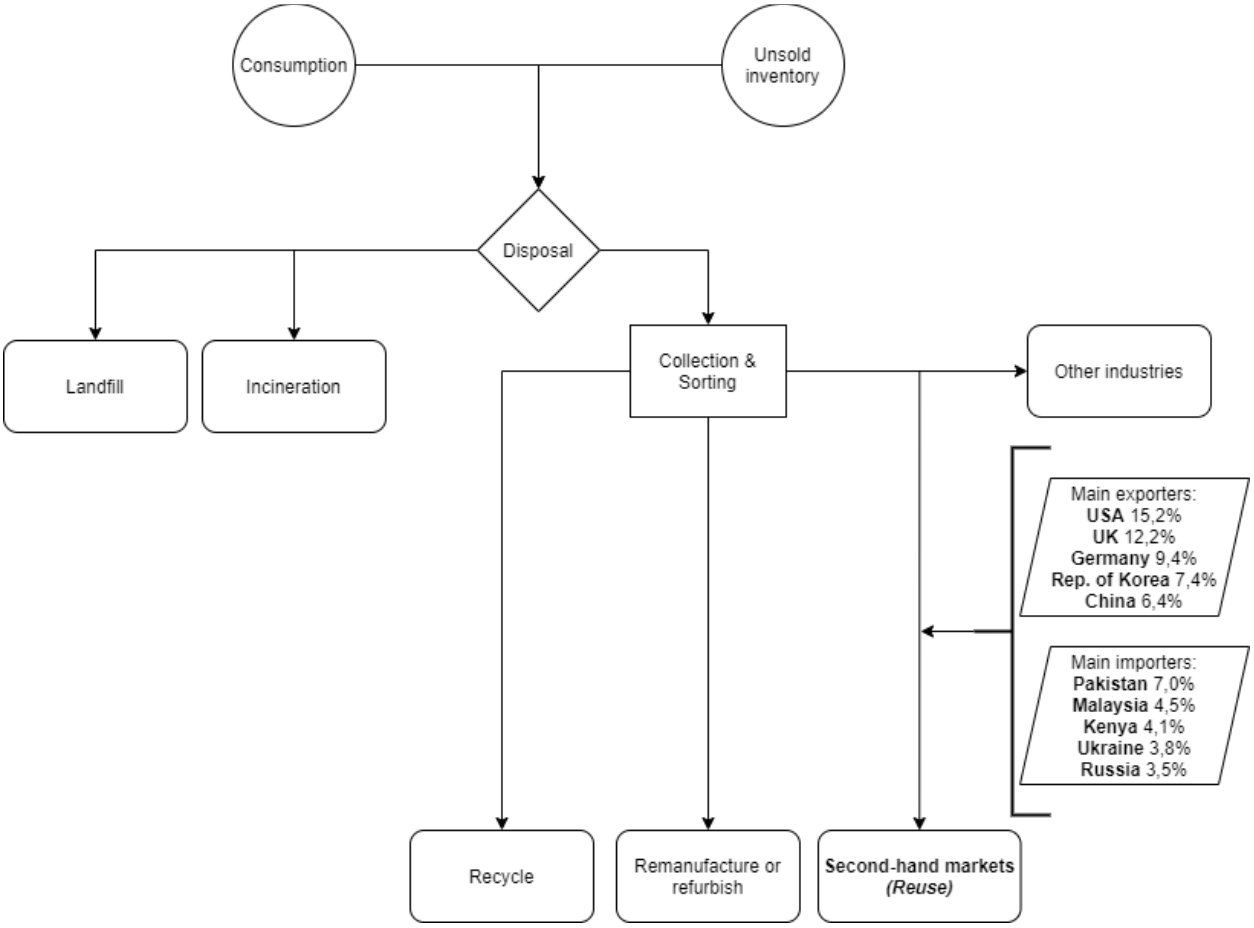
However, regional markets for donated apparel are already saturated where the consumption of clothing is higher (Environmental Audit Committee, 2019). Indeed, based on the United Kingdom situation, an oversupply of donated and collected garments will devaluate the product in the global market, which could bankrupt the already challenging collection and sortation industry (Environmental Audit Committee, 2017). A low value for worn garments imposes barriers to make operations depending on it profitable (e.g. collection, sortation, recycling) as margins are small (Paras et al., 2019).

As donated apparel floods international markets, they end up directly in landfills around the world when quality and sanitation are too low or when they reach their end-of-life. Plastic leakage from synthetic fibers in mismanaged landfills can heavily contribute to microplastics entering ecosystems and water sources (Quantis, n.d.).

Unfortunately, important barriers are still present as collection and sortation of used garments face logistic and financial obstacles to closing the industry's material loop (Paras et al., 2018; Fontell and Heikkilä, 2017). Collection and sortation are activities that divert post-consumer waste from landfills. For garments sent for reuse, it allows to select items that meet sanitation and quality requirements for thrift shops. Whereas, they are crucial for enabling the viability of recycling operations, as it preconditions waste for specific processes.

Another barrier is that garments are made with different blends of fiber materials and other components, such as buttons and zippers, which hinders their recyclability potential (Environmental Audit Committee, 2019). Hence, the valorization of textiles through recycling processes is still limited by technological and operational reasons (Paras et al., 2019; Fontell and Heikkilä, 2017). Additionally, consumers have a lower emotional value attached to their clothing which affects their perception of the garment when they want to dispose of it. It compromises the reuse or recycling of an end-of-life product because the consumer will not consider that it could still hold some value (Laitala, 2014).

Figure 4. Worn garments flow.



Note: Trade flow data from International Trade Center, Trade Map - Canada, retrieved online in August 2020

Secondhand-market's reuse and recycling processes, dependent on brands and retailers' ability to retrieve worn garments through reverse logistics, are examples of end-of-life strategies needed in driving and maintaining a sustainable transition in the apparel industry. For such results, stakeholders of the supply chain need to be supported by policymakers committed to put incentives in place and reduce barriers.

Governmental initiatives to close the loop

Jia et al. (2020) produced a systematic literature review highlighting barriers and drivers for circularity in the apparel industry. One of the main findings is how governments can exercise an increased incentive to lead businesses into a sustainable transition. Especially in the absence of a structure of channels for circular strategies in textiles, policymakers can adopt regulations and environmental policies that reduce costs for businesses willing to dispose appropriately of their textile waste (Jia et al., 2020). The different governmental strategies to address environmental issues linked to the apparel industry take many forms, from taxation to an extended producer responsibility program (EPR) to finance waste management. Kelderman (2019) highlights the importance of policymakers by listing and analyzing such public policies that could support an increase in recycling textiles.

On an international level, there is also an important recognition of the industry's problems. Indeed, one of the two UNFCCC's sectorial initiatives is dedicated to the apparel industry under the Fashion Industry Charter for Climate Action (UNFCCC, 2018). It invites industry leaders to coordinate in developing a roadmap for a sustainable transition that follows the Paris Agreement's decarbonization. The publications created by this Sectoral Engagement and the conversations it has started aim directly at firm's strategies and what companies can do to improve their supply chain's environmental performance. Yet, it remains a voluntary commitment from firms.

In terms of examples of environmental policies, the European Union already adopted policies to promote circularity in waste management for member countries (Jia et al., 2020). Notably, before this new EU policy, France spent years building the framework for an EPR-type legislature (Refashion, 2020) to deter retailers from disposing of unsold garments in landfills or incineration centers. It is key to support closed-loop alternatives.

An EPR policy shifts part of the costs of end-of-life treatment towards producers and retailers to finance disposal alternatives available in a territory. In addition, Refashion, the French organization responsible for the valorization of worn garments in the country, makes available a knowledge base and cheat sheets for ecodesign strategies. This way, they encourage and support

brands in the development of products and services that lessen the overall environmental impact of a garment by applying sustainable design choices that consider the product lifecycle.

Similarly, Sweden and the United Kingdom have different types of policies and programs either already in place or planned for the near future. In particular, Sweden recently proposed a tax on apparel containing hazardous chemicals, either manufactured in Sweden or imported, with the aim of "cost-effectively [reducing] the incidence or risk of exposure to, and spread of, substances in clothing and footwear that are harmful to the environment and human health" (Swedish Government Inquiry, 2020, p.23). Similarly, the UK will impose a tax on plastics in 2022, and they were recommended by experts to expand the criteria to include polyester and other petrochemical components used in garments (Environmental Audit Committee, 2019).

Canada signed the Paris Agreement and the Agenda 2030 that establishes the Sustainable Development Goals, one of which is responsible consumption and production (Department of Economic and Social Affairs, n.d.). That commitment and others international and national stances justify investing resources to deter retailers and brands from destroying product returns and unsold inventory. If nothing is done in the apparel industry, the targets that Canada committed to achieve in order to mitigate climate change cannot be expected to be met.

In 2009, the Canadian Council of Ministers of the Environment produced the Canada-wide Action Plan for Extended Producer Responsibility to advise and coordinate EPR policies for provinces on priority products (CCME, 2009). It comprises two phases and, today, Phase 1 products such as packaging, electronics and automotive components have provincial recycling programs (CCME, 2009; Government of Canada, 2019). However, textiles were part of an eventual Phase 2 for 2017 as the sector was deemed not ready yet. The recommendation was a timeline of 8 years to fill the lack of data, technology, and linkage between stakeholders (Giroux, 2014). Today, in 2021, only British-Columbia includes textiles in a future EPR plan (McDonald, 2017) and Ontario has the Ontario Textile Diversion Collaborative, which is a non-profit organization promoting municipal initiatives with the notable example of the City of Markham’s Textile Recycling Program Strategy (Marsales, 2016).

The disposal alternatives for garments, in Canada, remains in majority the reuse through companies and nonprofit organizations. Reuse might seem like a good strategy since it is higher

in the waste management hierarchy. However, 75% to 80% of donations do not meet the requirements for reuse by secondhand markets (Retail Council of Canada, 2020). Even if exported, these garments can remain unfit for reuse and end up in landfills around the world. Hence, there is a need for scaled-up viable recycling options to treat them and to deter retailers from destroying their end of season garments. Fashion Takes Action recently published "A Feasibility Study of Textile Recycling in Canada" that goes in a similar direction of analysis, conclusions and recommendations (Fashion Takes Action, 2021).

Considering retailers and brands burn their unsold inventory and returned products, further analysis of available tariffs and regulations is required to avoid creating those additional incentives that would promote the destruction of products. Especially in the case of incineration for energy recovering, a company could even receive a tax benefit for destroying inventory (Napier and Sanguineti, 2018).

Discussion

Overall, this communication explores the link between fast fashion garment production and textile waste issues. The linearity of the industry ensures that an increase in production will worsen garments' end-of-life environmental impact. Sustainability in fashion is more often approached through design and material choices than through economic lenses. In particular, the destruction of unsold inventory exemplifies how a firm's decision-making in the current industry state and regulations leads to inefficient sustainable choices. Moreover, this overview discussed the known causes of a garment's environmental impact, how little is known for the end-of-life phase and some reasons why.

These are key insights for Canadian policymakers, as it is a crucial knowledge for the catching up of federal and provincial regulations compared to the countries in the forefront of the fight against the impacts of fast fashion. The solutions that governments must put in place are broader than environmental policies, as retail and international trade regulations also hold a potential to steer a systemic transition.

This document contributes to a field in need of attention from researchers and policymakers, since the gap to fill in available data and knowledge of stakeholders is significant. Specially, it is

one of a handful of works done that considers the Canadian context and economic aspects of the industry. Yet, transitioning fashion towards more circular business models is crucial to change the environmental impact from the global consumer goods industry.

However, the overview conducted in this work is limited to garments sold in physical stores. Whereas brands and retailers currently have adopted omnichannel strategies that include multiple different ways of selling the same product. Online shopping, in particular, has the potential to add relevant insights to fast fashion environmental issues.

Conclusion

Apparel consumption is responsible for environmental damages and social issues that have rightfully been on the spotlight of discussions on the sustainability of consumable goods. Fast fashion is perceived to heavily contribute to these problems with its high speed of new trend cycles and low-quality garments. The impact is two-fold with an aspect of overconsumption and, yet also an overproduction. In the management of the excess stock at the end of a selling season, retailers and brands have incentives to destroy it instead of recovering its value. The elimination of unsold inventory is a strategy closely linked to the linearity of practices related to fast fashion.

In trying to understand why some firms decide to destroy their unsold inventory, the advantages of fast fashion for retailers and brands were highlighted. Namely, a faster supply chain enabling the design of a garment which fashion content's is closer to the present trend. Indeed, one of the goals of a fast fashion brand or retailer is to quickly bring to market a product that will satisfy the maximum number of consumers for a selling season. One downfall is the production of lower quality garments that have low value when the trend fades. The nuances of this rapid product obsolescence and the demand uncertainty add to the issues of the linear model of the current apparel industry. It contributes to the generation of excess stock that retailers and brands need to dispose of in order to free in-store space for new apparel collections. The decisions taken during production according to fast fashion requirements aggravate the post-consumer waste management issues since available end-of-life treatments are similar for unsold inventory and worn garments.

Textile waste issues have become global, and they contribute to the already heavy environmental and social impacts of the apparel industry. Unsold inventory directed to landfills and incineration centers worsen waste management challenges. Hence, there is a need for a systemic adoption of solutions both for better production practices and end-of-life alternatives. To further understand where these strategies can be applied, an overview of the fashion industry supply chain was conducted. It highlighted how opaque access to data is and how retailers have become the new key decision-makers.

The globalized and fragmented characteristics of the apparel industry become evident when tracking flows of main materials and fabrics used to manufacture garments. It shows how North American, and some European countries have become "consumers" as finished products are imported in greater quantities than anywhere else. However, the Harmonized System codes used for analyzing international trade are limited when trying to understand textile waste flows, which hinders the comprehension of end-of-life impact. Generally, unsold inventory does not cross borders, because it is treated by local or regional disposal facilities, commonly landfills and incineration centers rather than recycling operations. There is the exception of reuse when unsold products are sent to NGOs and second-hand stores as corporate donations. Although, if they do not meet the criteria to be sold in other national second-hand markets, these end up as waste around the world. Globally, there is a general lack of data on textile waste. However, available data shows that textile waste is a problem requiring actions. Hence, the first steps for efficient policymaking would be to facilitate tracking of waste when it crosses borders through new types of commodity codes and to further undergo waste characterization studies. The latter is a localized and small-scale effort, but both are needed to have a clearer portrait of the situation to develop appropriate recovery solutions.

As retailers became the central stakeholders thanks to their closeness to consumers' feedback and private labels, their responsibilities have been increased regarding production and disposal of garments. There is a need to reduce production quantities of low-quality garments that are incompatible with existing recycling processes. Ecodesign, which occurs on the drawing table, helps promote preferred materials, certifications that influences downstream manufacturers, and reduce the product's overall environmental impact. It also plays a significant role in facilitating

the preconditioning of garments for recycling by encouraging detachable components or a homogeneous material choice.

Opportunities for closed-loop strategies exist but have yet to be applied into large scale operations. Significant technical barriers strengthen the industry's linearity by preventing these initiative's growth. Fabrics made of blended fibers, the most widespread collection method, and manual sorting of garments result in batches of heterogenous materials, which jeopardize recycling operations. These obstacles generate a larger volume of residual waste because landfills are more available, and often less costly, than recovery alternatives. New business models are needed in the fashion industry, with a focus on cleaner production and consumption that reduces waste. This transition needs governmental support to allow better practices to become the new industry standard.

The unrestrained destruction of unsold inventory worsens these textile waste management issues by increasing end-of-life garments. Public policies are key tools to uphold the rise of alternative disposal methods or restrict impactful behaviors. Subsidies, or taxes, can help finance recycling operations and assist in covering the costs of barriers to larger scale operations. Whereas regulations on riskier materials and processes can limit the scale of their environmental impact. Similarly, constraints on unsold products' destruction can hinder, if not ban, the possibility of using landfills. The French example of forcing retailers to keep their products in a second-hand market is of particular interest as firms are required to contribute to the financing of disposal systems designed to recover at least part of the product's value. France, Netherlands, Sweden and the European Union display a global leadership regarding support of alternatives addressing the issues of textile waste management. Canada shares the "consumer" status of those countries, but federal and provincial initiatives are still to be implemented. As Canadian policymakers took similar commitments towards the UN Sustainable Development Goals and the Paris Agreement as did those other countries, there is a need to adopt a similar attitude.

As sustainability in fashion increases as an issue, researchers, firms, and policymakers should focus on textile waste. Reduction of the environmental impact related to our consumption of garments is linked to an ecosystem of interconnected solutions and a decline of damageable behaviors such as the destruction of unsold products.

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