

Rethinking Packaging

A DHL perspective on
the future of packaging in
the logistics industry



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Preface

Packaging is fundamental to the logistics industry. It makes products safer and easier to handle, and protects them during storage, transport, and delivery. Modern packaging is so ubiquitous that it is easy to forget just how remarkable it is. Centuries of innovation and refinement have produced packaging technologies that deliver high performance in a bewildering range of applications and at extremely low cost.

Yet there is growing evidence that today's approaches to packaging are struggling to meet the changing needs of companies, consumers, and the wider environment. This is exacerbated by the fact that different stakeholders have different, often unaligned packaging needs. The result can be primary, secondary, and tertiary packaging with little consideration of impact on the supply chain ecosystem. The increasing speed, scale, and complexity of modern logistics processes – especially those driven by the growth of e-commerce and omni-channel retail – are driving up packaging costs and creating

inefficiencies in the downstream supply chain. Companies want their branded packaging to present them in a positive light, but consumers are frustrated if this packaging is hard to use and difficult to recycle. Packaging waste represents a significant environmental challenge.

As logistics professionals, we have been thinking about how these developments are likely to impact the packaging solutions seen in today's supply chains. We also wonder how new approaches to packaging will shape future logistics operations and processes.

Our objective in producing this report is to share our findings and help you answer the following questions:

- What trends are driving change in packaging?
- How are industries and their packaging needs evolving?
- How will packaging innovations shape the near future of the logistics industry?

Across all sectors, companies are shifting to greener logistics operations, recognizing that it is now necessary to rethink packaging activities from a sustainability standpoint.

Looking ahead, we believe that the adoption of new packaging optimization tools, materials, and handling technologies will significantly boost efficiency and productivity. In addition, the broader adoption of IoT technologies at the parcel level will make packaging smarter and more connected. That in turn, will drive changes in the operation of supply chains and logistics processes. It will also deliver benefits in terms of better capacity utilization, sustainability, and customer experience.

We hope this report improves your understanding of current packaging innovation and inspires you to consider new approaches to your own packaging challenges.

At DHL, we believe that reaching the next level in packaging performance

will require close collaboration between supply chain experts, packaging specialists, and customers. On behalf of us all at DHL, we hope you enjoy this read as much as we enjoyed compiling it for you. We look forward to rethinking packaging together with you.



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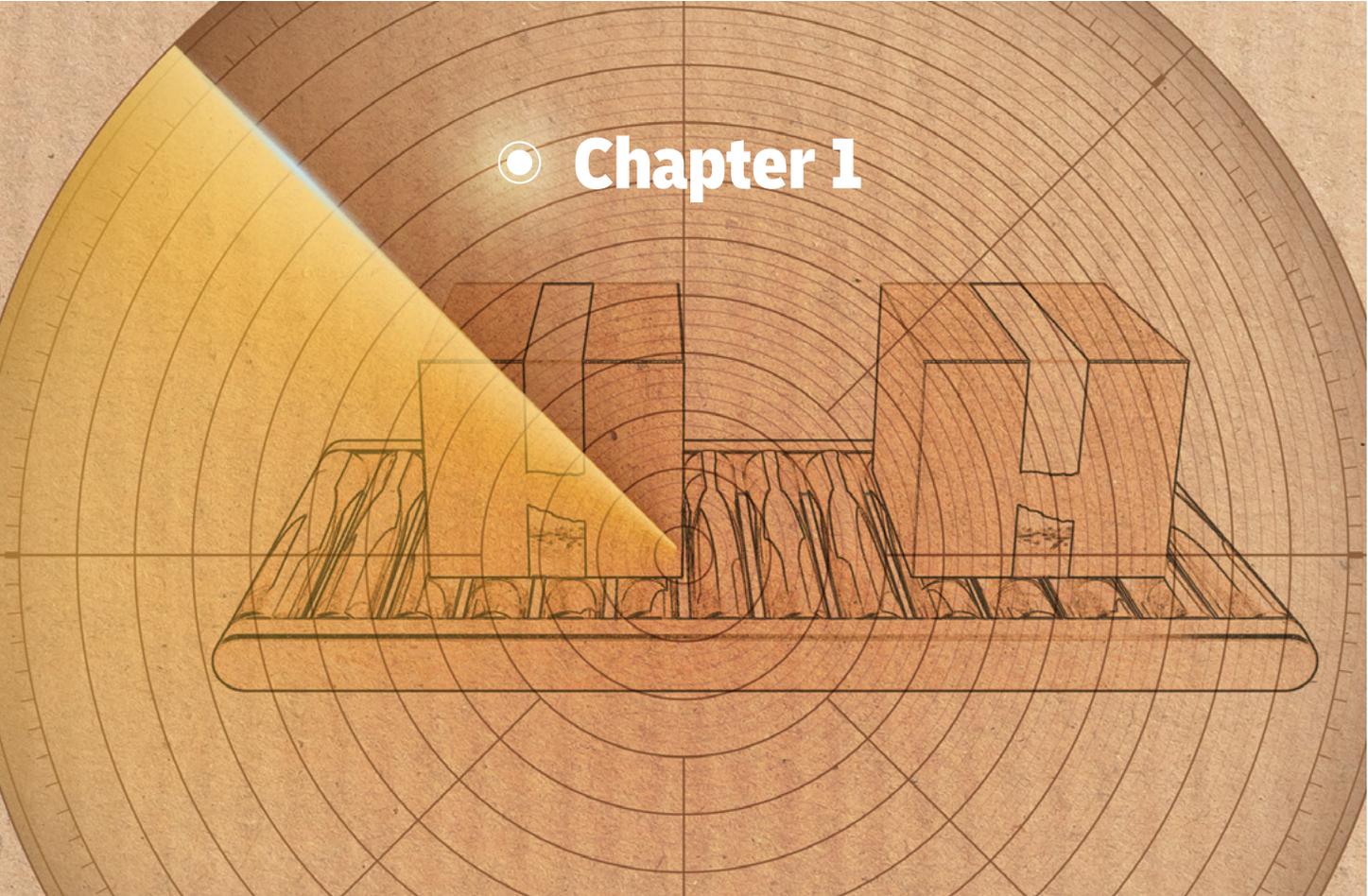
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● Chapter 1

Sometime after our earliest ancestors first developed tools, they needed something to carry them around in. Animal skin bags, clay pots, and woven baskets were among our antecedents' earliest personal possessions. Since, then packaging has evolved over time, always adapting to the changing needs and requirements of society. Nowadays, packaging is struggling to keep up with the shift in customer behavior, rise in e-commerce, and growing demand for sustainability which leads to the need to rethink packaging.

● Why rethink packaging?

1.1 THE EMERGENCE OF A NEW PACKAGING ERA

Throughout history, the growth of trade and the development of packaging have been intimately linked. Reliable, robust, inexpensive packaging has helped humans to exchange goods over ever-increasing distances.

The relationship between packaging and trade remains strong today. In the past decade, the global packaging industry has enjoyed steady growth, fueled by an average 25% per year increase in cross-border e-commerce sales due to expansion of new markets and a rising wealth of middle income globally.

In 2018, the global packaging industry was worth USD \$886.1 billion (figure 1). Asia-Pacific countries are the largest consumers of packaging, accounting for 44% of the world total. That position reflects both the region's large population, with its significant domestic markets, and its role as a manufacturing center supplying the rest of the world. North America and Western Europe take second and third places, accounting for 23% and 19% respectively. The gap is expected to widen: demand for packaging is forecast

to grow at 4.5% a year in Asia and Africa and by only 1% a year in North America and Europe.

It bears mentioning that packaging is an incredibly vast, diverse, and complex topic that reaches far beyond the logistics industry.

Packaging needs and requirements are highly individual depending on regions, sectors, and customers. The world of packaging can be segmented into three levels:

- 1. Primary packaging:** the inner enclosure that is in direct contact with the product itself (e.g. a bottle filled with wine)
- 2. Secondary packaging:** the outer emballage and filler material designed to contain multiple primary packages and maintain their original condition (e.g. a carton enclosing multiple bottles of wine)
- 3. Tertiary packaging:** this consolidates multiple primary and secondary packages to facilitate handling, transport, and storage (e.g. a pallet loaded with multiple cartons)

For the purposes of this trend report, we will focus on the changing role of secondary packaging and the innovations coming to market to address its challenges and opportunities.

Modern packaging is the result of decades of evolution. Traditionally, packaging has performed three fundamental roles:

- **Protection:** packaging defends a product against loss or damage in the supply chain journey, helping to ensure quality
- **Transportability:** packaging facilitates the easy, cost-effective handling and storage of products, promoting efficiency in the supply chain
- **Communication:** packaging provides relevant information to supply chain participants, from warehouse pickers to delivery couriers and end recipients

These roles remain essential but now companies are increasingly asking packaging to work harder on their behalf. As examples, consider the changing role of packaging fueled by digitalization in three areas: **brand experience, security/traceability, and connectedness** (figure 2).

Global packaging consumption by spend

Packaging consumption
2018: **\$886.1 billion**

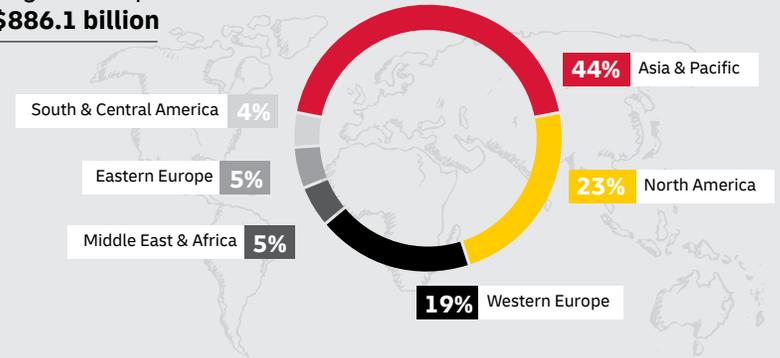


Figure 1

Shift in packaging functionalities

Packaging has evolved to serve **more functionalities than before**



Figure 2

Figure 1: Global packaging consumption 2018 by region. Source: Smithers

Figure 2: Shift in packaging functionalities. Source: DHL

- Brand experience:** especially in the fast-moving consumer goods (FMCG) sector, companies have always used packaging design to communicate brand values and attract the customer's eye on crowded shelves. As more retail activity moves online, however, a customer's first experience of a product's packaging may occur after making the initial purchase, at the point of delivery to their doorstep. Far from reducing the significance of packaging, this presents brands with a new opportunity to surprise, delight, and impress the customer. This changes the role of packaging: it becomes an important touchpoint with the consumer to deliver an outstanding brand experience.

- Security and traceability:** one consequence of the development of global supply chains has been the rise in product-related crime, including theft and counterfeiting. Companies see improvements to packaging as one weapon in their war against these threats. This requirement has driven innovations in areas such as secure identity-marking systems, tamper-evident closures, and real-time track-and-trace localization.

Packaging ecosystem

Packaging has to serve the **many different needs of multiple parties**

>> Brands

- Product protection
- Cost of packaging
- Brand experience

>> Logistics

- Easy handling & storing
- Robustness & stackability
- Space utilization



>> Consumers

- Unboxing experience
- Easy returns
- Sustainability

>> Retailers

- Presentability
- Shelf utilization
- Retail-ready packaging

Figure 3

- Connectedness:** beyond security, the use of packaging solutions that contain smart communication technologies (e.g. sensors, tags, and codes) are also on the rise. These are going beyond monitoring and communicating change in condition of the package while in transit to drive more proactive management of supply chains. Digitally connected packaging benefits product

manufacturers and logistics professionals not only with managing supply chain processes, but also with differentiating their brands by delivering unboxing experiences that surprise and delight customers.



Figure 4

A single item of packaging is touched by many different players including brand designers, retailers, logistics service providers and, ultimately, the end customer. In addition, at different stages of the packaging lifecycle the ecosystem can even extend to material suppliers, packaging manufacturers, and product manufacturing teams. Each of those stakeholders has their own set of needs and priorities, and their requirements are not always aligned.

Moreover, packaging design and specification decisions may be made on primary and secondary packaging levels by a small subset of stakeholders, with little consideration of impact further downstream.

Figure 3: A challenging packaging ecosystem with conflicting and congruent interests among all involved parties. Source: DHL

Figure 4: The rise in e-commerce has a profound impact on packaging requirements in terms of durability and robustness. Source: DHL

1.2 TRENDS ACCELERATING THE NEED TO RETHINK PACKAGING

Today there are signs that packaging is struggling to meet society's changing needs. In particular, existing packaging systems are being tested by three major trends:

- 1. The rise of e-commerce and direct-to-consumer delivery**
- 2. The growing need for packaging convenience and a delightful customer experience**
- 3. Pressure to improve sustainability, reduce waste, and eliminate pollution from packaging material**

In the following section, we review how these trends shape the packaging demands of modern society.

Driven by globalization and e-commerce, the overall volume of products shipped is rising, as is the share of delicate or sensitive products. Packages are travelling further through longer, more complex cross-border logistics networks. Customers are also demanding higher

quality standards - business customers want to manage lean or zero-inventory supply chains and consumers insist their purchases arrive in perfect condition every time.

The e-commerce effect

The spectacular rise of e-commerce as a major retail channel for many product categories is having a profound impact on packaging requirements in terms of robustness, sustainability, and brand experience. What's more, the e-commerce user experience and buying behavior are setting expectations for business-to-business (B2B) shipment transactions. Manufacturers of spare parts, machinery, and equipment accessories are increasingly keen to provide a business-to-consumer (B2C)-like experience in their B2B activities.

In traditional brick-and-mortar retail, most products are packed on pallets and shipped in bulk from a distribution center (DC) to the retail store. The model is streamlined, linear, and simple.

The journey taken by a product through the e-commerce supply chain couldn't be more different (figure 5).

Comparing parcel journeys in the supply chain

Traditional retail



E-commerce



» In e-commerce, parcels are handled up to 20 times more than in traditional retail

Figure 5

An e-commerce package is handled 20 times more frequently on a journey from the DC to the consumer's home than when it is transported on a pallet to a retail store. With each of those touchpoints presenting an opportunity for the item to be dropped or damaged, e-commerce supply chains create much higher requirements for packaging robustness and product protection. While brick-and-mortar retailers typically require packaging to be drop tested from five different angles, for example, leading online retailers ask for 18 separate drop tests.

Future e-commerce innovations are likely to intensify packaging demands. Leading logistics providers are now on their fourth or fifth generation of drone delivery projects, and exploring delivery with unmanned ground vehicles. Combined with growing demand for unattended delivery formats, packaging will need to evolve to allow items to be left outside the customer's home, exposed to inclement weather and the risk of theft.

Figure 5: The e-commerce supply chain journey is more challenging than before, requiring more robust and protective packaging. Source: DHL

TRENDS SHAPING PACKAGING STRATEGIES IN LOGISTICS

Importance of packaging in the next 3-5 years

9 out of 10 companies say packaging is high on their agenda



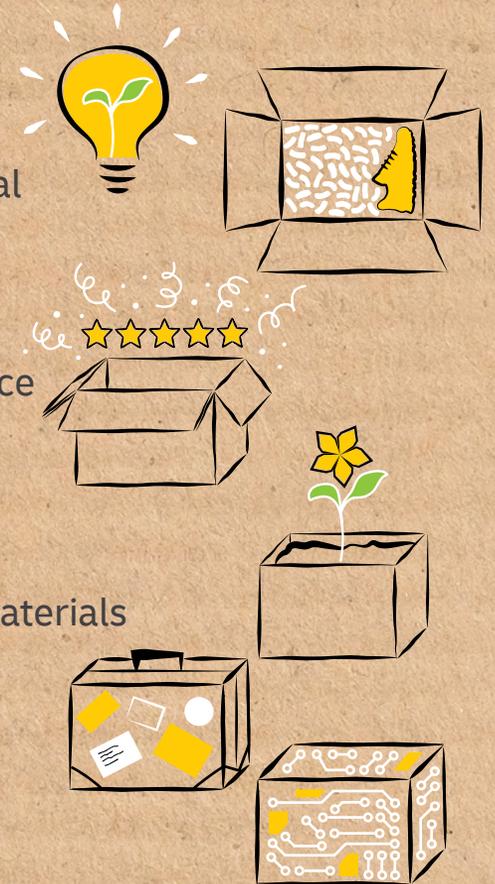
Current challenges related to packaging in logistics

- 1 Maintain a reasonable packaging spend
- 2 Reduce the incidence of shipment damage
- 3 Optimize transport capacity



Top trends shaping the packaging strategy

- 1 Demand for sustainable packaging material
- 2 Public awareness of packaging waste
- 3 Delivering outstanding customer experience



Top focus areas for packaging in the near future

- 1 Introduction of eco-friendlier packaging materials
- 2 Implementation of re-usable packaging
- 3 Adoption of smart packaging solutions

The drive for convenience and shift in customer experience

While product protection in transit is highly relevant this needs to be balanced with packaging ease of use for the customer. In the brick-and-mortar retail environment, packaging is often designed to thwart theft or tampering, for example through the use of rigid clamshells with sealed edges.

Freed from the need to protect products from shoplifting, e-commerce retailers have encouraged the development of packaging designs that prioritize access with minimal effort (figure 6). Amazon's packaging certification guidelines, for example, promote the concept of 'frustration-free packaging', which requires packages to be easily accessible, recyclable, and designed to minimize waste. The company says that, since it began the program in 2008, its packaging guidelines have removed 180,000 tons of packaging, including 307 million boxes, from the supply chain.

Not all the new demands of e-commerce have been as easy to fulfill. The high service levels provided by market leaders have substantially increased consumer service expectations. In developed markets, e-commerce customers have

come to expect next-day or even same-day delivery, and even perceive this service level as standard. Results from DHL's recent survey also reflect this new expectation with respondents citing the need to deliver an outstanding experience among the top three trends shaping their packaging agenda.

Consumers are equally intolerant of quality problems. Almost 50% of e-commerce customers said that receiving a damaged item would make them less likely to purchase from the same retailer again.

Customers are also increasingly agitated about wasteful and inefficient packaging. If you shop online, you have probably personally experienced receiving a large box containing just one or two small items and a lot of void-fill material (figure 7). This tends to trigger derisive comments on social media, creating reputational headaches and higher costs for online sellers.

As e-commerce erodes the traditional value of packaging as a stimulus to purchase, it also creates new opportunities for the delivery process to play a central role in the customer's overall experience of a brand.



Figure 6



Figure 7

Figure 6: A comparison of packaging examples before and after re-design with focus on ease of use. Source: DHL
 Figure 7: Inefficient packaging containing just one or two small items and a lot of void-fill material immediately causes customer frustration. Source: Shutterstock

OVERSIZED AND ODDLY SHAPED

E-commerce has helped to drive an increase in the variety of products shipped. Large items such as bicycles and furniture that would once have relied on specialized transport services are now shipped through the parcel networks of logistics companies. Other products, such as groceries, may be fragile, sensitive, and time critical.

These types of shipment have the potential to introduce significant handling and operational challenges for logistics service providers.

They require specialized packaging solutions to ensure product integrity and to protect personnel, equipment, and other packages in the system.

Also packaging can significantly ease item handling in the last mile. Bulky goods can be more simply received by the customer via e-commerce if these items come with pre-cut handles, hoist markings, stacking restrictions, and unpacking instructions.



Figure 8



Figure 9

Every retail product has two moments of truth in its lifetime: the moment when it is purchased and the moment when it is first used. The e-commerce journey inserts an additional moment: after the online purchase, there is the moment of receipt. The delivery experience has become a potential magic moment in the e-commerce journey, one that can make the difference between winning or losing a customer for life.

Leading e-commerce players have found ways to turn the delivery process from a hygiene factor into a critical opportunity to secure customer loyalty. The ingredients are simple in concept but difficult to execute at large scale, including perfect order fulfillment, personalized packaging, flexible delivery options, and a free, convenient system for returns. Among all these operational challenges, brand executives have to remember that the packaging itself must be simple and elegant to win the hearts of customers.

Figure 8: There's a growing need for specialized transport services as more large items are ordered online. Source: DHL

Figure 9: The delivery experience as a magic moment in e-commerce supply chains. Source: DHL



Figure 10

Packaging has also found an unexpected new marketing role. Canadian YouTuber Lewis Hilsenteger's Unbox Therapy channel boasts 15 million followers and has racked up more than 3 billion views (figure 10). Fans tune in for the simple pleasure of seeing Hilsenteger remove the latest consumer products from their packaging.

'Unboxing' videos like these have now become a staple of online and social media review sites, giving savvy packaging manufacturers and product marketing teams a valuable opportunity to attract attention, appreciation, and sales from existing and new customers.

The best product manufacturers and brands should consider their packaging design and out-of-box-experience at the outset of a product's development, not as an afterthought once the product is developed. This will require

close collaboration between logistics professionals and product development organizations to realize packaging that meets the needs of all parties involved, not just the product itself.

The sustainability challenge

Today's packaging systems have a significant environmental footprint. Analysis of e-commerce parcels, for example, shows that around 24% of their volume is empty space. In the fast fashion industry this number tends to be even higher due to the lack of structural rigidity of clothing and accessories. This adds significant additional costs for the industry. Increasing the package utilization rate benefits all parties in the e-commerce supply chain, from operations to the customer and the environment. Simultaneously optimizing fill density and package protection, while operating at high speed and large scale, remains perhaps the most significant packaging-related challenge to date.

Then there's plastic. Offering a unique combination of light weight, effective protection, and low cost, plastic packaging accounts for around a quarter of the estimated 8.3 billion tons of the material produced since it was first commercialized

in the 1950s. In 2016, citizens of the EU generated 170 kg of plastic packaging waste per person.

Only 14% of the plastic packaging used globally is recycled today. When plastic waste is sent to landfill, it takes over 450 years to decompose. The useful time of plastic is just a fraction of the time it takes to decompose (figure 11). Furthermore, significant volumes of plastic are not captured in properly managed waste streams and instead enter the environment. According to the Ellen MacArthur Foundation, at the current rate of accumulation, the mass of plastic in the world's oceans will exceed the mass of fish by 2050.

Packaging lifetime comparison

Time of use vs. time to decompose



Figure 11

Figure 10: Unboxing videos enjoy large popularity and have become a powerful marketing tool. Source: YouTube

Figure 11: A comparison of the time plastic is used and the time it takes to decompose. Source: DHL

Public concern over the impact of plastic on the environment is also driving consumer demand for alternative packaging solutions. A survey by International Post Corporation found that 60% of respondents want parcels to use sustainable packaging. However, consumers are only willing to pay a small premium for greener packaging.

Results from our own customer survey highlight public objection towards plastic and packaging waste as a key indicator that change is needed. Big companies are indeed reacting to this shifting consumer sentiment.

Sporting goods maker Adidas plans to entirely switch to recycled plastics by 2024. Apple is using post-consumer recycled and bio-based plastic in many of its latest products. Furniture retailer IKEA now uses only fully recyclable packaging materials, and FMCG group Colgate-Palmolive says it will switch to recyclable packaging across its portfolio by 2025.

Consumer concern about the environmental impact of packaging waste is even encouraging the development of entirely new businesses. Packaging-free stores such as German chain Unverpackt stock only loose, bulk goods, requiring customers to bring and fill their own reusable containers (figure 12).



Figure 12

If consumer pull isn't enough to force some companies to change their packaging systems, regulators may push them into action. Governments around the world are introducing restrictions or charges on disposable plastic items. Indonesia has banned single-use plastic bags, for example, while France requires plastic cutlery, plates, and cups to be made from biodegradable materials. Worldwide, more than 90 countries have imposed outright bans on certain single-use plastic items and a further 36 regulate these products with taxes or fees.

Together, the forces outlined in this chapter are putting today's packaging systems under increasing strain. Product manufacturers, retailers, and logistics service providers are struggling to optimize packaging in the face of rapid and significant shifts in demand. Failure to do so increases the total costs of packaging due to inefficiencies from overpacking, lower utilization, and shipping of empty space across the supply chain.

Consumers are frustrated too, enduring packaging that is difficult to use and which imposes a significant waste-management burden. And all the while, huge and growing volumes of packaging waste are damaging the environment.

Addressing these issues will require stakeholders across the packaging supply chain to rethink their technologies, processes, and business models. In the next part of this report, we will take a deeper dive into the industry-specific developments and trends that are

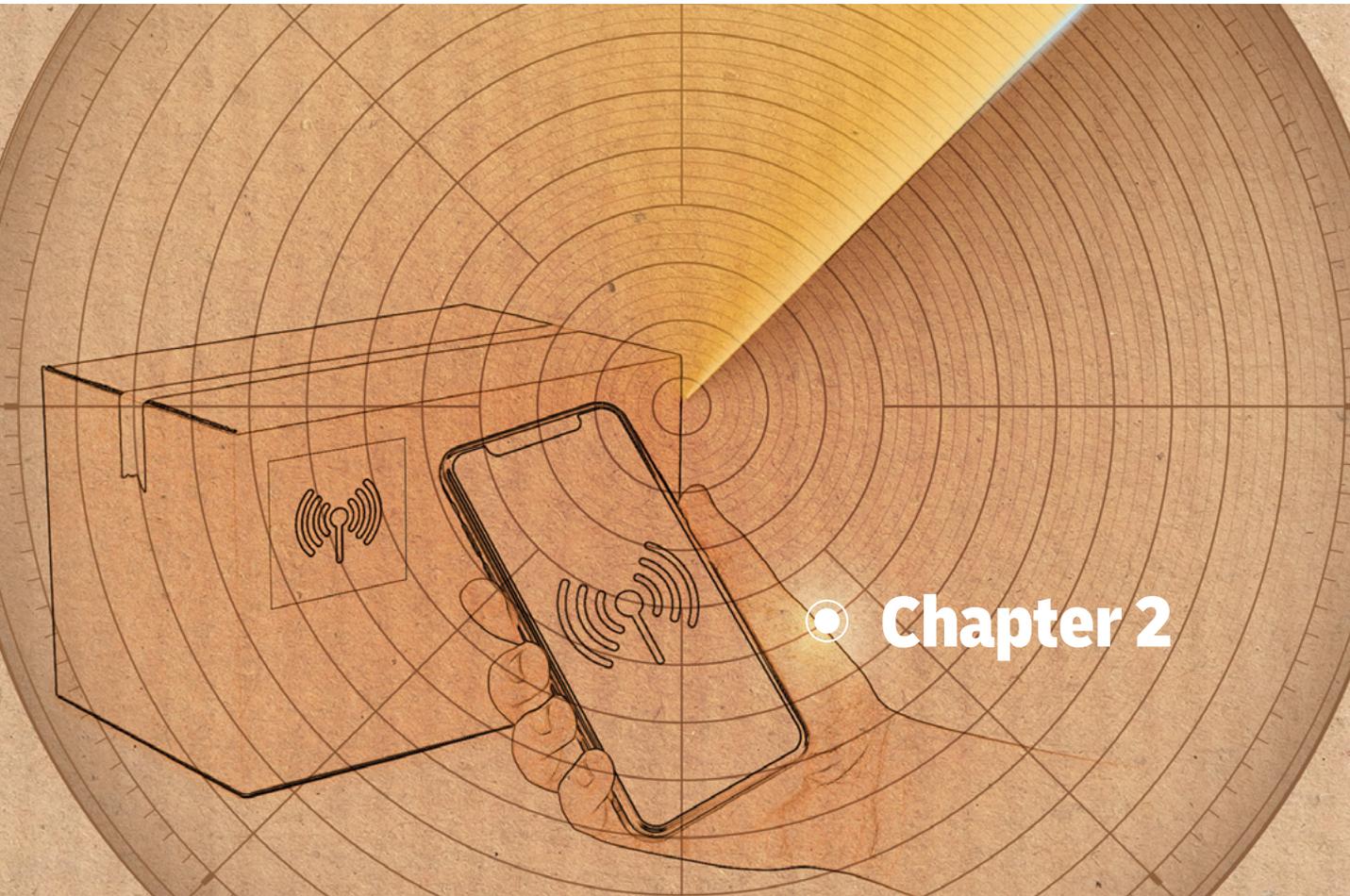


Figure 13

reshaping packaging demand in key industry sectors. Then we will examine some of the innovative emerging opportunities that might help companies respond to these demands.

Figure 12: Packaging-free supermarkets enjoy growing interest from eco-conscious end consumers. Source: Unverpackt Mainz

Figure 13: The Adidas x Parley collection is made of at least 75% upcycled marine plastic waste. Source: Adidas



Every industry's packaging choices are being shaped by the common challenges described in the previous chapter. Specific sectors and clusters of sectors also have their own technical demands, commercial pressures, and supply chain characteristics, however. In this chapter, we examine those factors in three major areas and show how they are leading these industries to adopt different packaging approaches, technologies, and solutions.

☉ Sector-specific packaging needs and innovations

2.1 TECHNOLOGY AND AUTOMOTIVE – EMBRACING THE CONVERGENCE OF TWO INDUSTRIES

Packaging to power a connected world: semiconductor supply chains

Maintaining modern society's reliance on computing power, smartphones, and 24/7 internet access necessitates highly globalized and sophisticated semiconductor supply chains. This dependency is intensified by competitive pressures in the technology industry to accelerate the time to market, requiring ever-faster movement of raw materials and finished goods around the globe.

The packaging used for raw materials, component parts, and finished products in the technology industry must therefore withstand rapid, long-distance, sometimes harsh journeys to the end customer. Delivering servers to mission-critical data centers and devices that support vital telecommunications and internet infrastructure requires adherence to strict standard operating procedures (SOPs) with near-zero defect levels.

Adding to these challenges, semiconductor products are highly sensitive to shock, vibration, humidity, extreme temperatures, electrostatic discharge, and other environmental factors. And they tend to be small, lightweight, and of high value.

This means that any loss due to damage, even if this affects just a single package, is likely to be costly and disruptive. Our recent customer survey revealed that shipment damage is still one of the top challenges related to packaging, and among technology supply chain leaders it might even be rated as the most critical challenge.

As a result, security and end-to-end supply chain visibility are high priorities for manufacturers. Packaging must physically protect smart, connected, semiconductor products and as such will increasingly leverage IoT technology to deliver the needed visibility. Advanced condition monitoring systems from companies like Roambee and Tive are bringing high performance condition sensors to the market. These are purpose-built for use on secondary and tertiary packaging, and are fast becoming a favorite in semiconductor shipments. The combination of in-transit sensors and online sensor platforms is sure

to enable exciting new capabilities. We can anticipate a growing number of applications on a broadening range of shipments as sensors become cheaper and more widely available through economies of scale.

Car or device? Packaging connected, autonomous vehicles

The semiconductor supply chain is currently expanding into a new industry – automotive. This sector is in the middle of what can be described as the most significant period of disruption in its history. Three major trends – electrification, connectivity, and autonomy – are together transforming the car from a mechanical device into a high-tech mobility platform bristling with sensors, silicon, displays, and advanced electronics. As the proportion of a vehicle made from these high-tech products increases, the supply chains and supplier ecosystems of the automotive and technology sectors are irreversibly converging. Even traditional automotive component supply chains are starting to take on more of the characteristics of the high-tech sector. Globalized production systems now require parts to travel long distances between supplier and OEM.

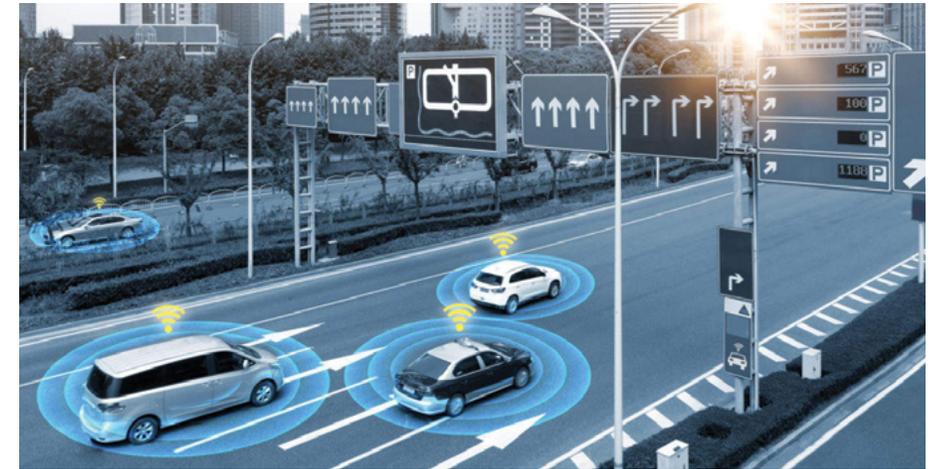


Figure 14

That is challenging the industry's established just-in-time delivery models, which have always relied on short loops and made extensive use of returnable container systems between different production plants. And parts aren't just moving further, they are becoming bigger and more delicate too. Vehicle manufacturers now ask their suppliers to take on more assembly work, providing complete modules such as fragile windshields, infotainment dashboards, and light assemblies. It is important to protect the sensitive surface of those products from damage through shifting and vibration.

Figure 14: Next-generation connected cars employ an increasing share of computer, sensor, and communication technologies. Source: Verdict

Figure 15: Transportation of sensitive semiconductor and silicon components requires high levels of protection to ensure zero-defect on arrival. Source: Nano Dimension

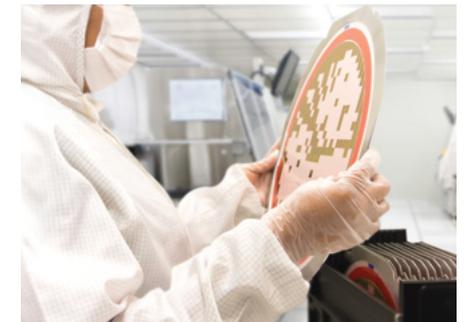


Figure 15

Electric vehicles: batteries on the move

Transportation accounts for around 20% of global energy consumption and passenger vehicles are responsible for a tenth of all carbon dioxide emissions. Under pressure to play its part in the transition to cleaner energy sources, the automotive industry is placing a big bet on electric vehicle (EV) technologies. Forecasts project 8.4 million units by 2025 or 7.7% of the total passenger vehicle market, with more than half of those vehicles predicted to be sold in China. Uptake of EVs is likely to

increase even faster later in the decade, as the falling cost of battery technology makes them directly cost-competitive with conventional powertrains.

All modern EVs rely on lithium-ion batteries for energy storage, and this technology looks to remain the primary approach for the foreseeable future. In addition to being of high value at nearly 50% of a typical EV's component cost, lithium-ion batteries present significant challenges for the entire supply chain and its players.



Figure 16

Transportation, handling, storage, and recycling of batteries are tightly regulated as they need to comply with UN dangerous goods regulations and IATA guidelines. That creates a requirement for certified packaging, equipment, and operational staff. Moreover, those requirements differ depending on the types of battery involved, the chosen transport mode, and the point in each battery's lifecycle. Defective or potentially defective batteries, for example, introduce heightened risk of fire and chemical contamination, creating the need for extreme care in packaging, handling, transportation, and storage.

The industry is looking to develop standardized manufacturer-agnostic processes for battery logistics, but the solutions for damaged batteries today remain costly, complex, and fragmented. Appropriate battery packaging solutions like the LiBa-solution from the German provider GelKoh are a key component to support secure, compliant transportation and storage of batteries.

As a founding partner of the Formula E Championship, DHL manages the transport operations of this worldwide racing series and moves 450 tons of freight including 40 race cars, 45 lithium-ion batteries, and broadcast equipment



Figure 17

around the globe every year. Packaging and handling for this highly specialized equipment requires robust and secure crates which can be used across all types of transport mode and which comply with global standards and regulations.

Figure 16: Electrification is making its way into logistics with increasing impact into last-mile delivery in logistics operations. Source: StreetScooter GmbH

Figure 17: As a founding partner of the Formula E Championship, DHL is pushing the boundaries of an all-electric motorsport. Source: DHL

2.2 HEALTHCARE AND LIFE SCIENCES – FOSTERING GROWTH TOWARDS PATIENT-CENTRIC TREATMENT

The global market for pharmaceuticals and other healthcare products is enjoying steady long-term growth, driven by the needs of an aging population in developed economies and improved access to healthcare in emerging markets. As markets expand so too do packaging needs. Pharmaceutical packaging is forecasted to grow by around 7% a year over the next five years, making it a subsector worth over a \$100 billion a year by 2024.

Packaging safety, security and compliance

Pharmaceutical packaging systems are primarily designed to safeguard the integrity and efficacy of products. Many pharmaceutical products have a limited shelf life and are easily damaged by high temperatures and other environmental effects. Distribution of these products depends on tightly managed – and strongly regulated – temperature-controlled distribution chains all the way from production to point of use.

The sensitivity, high value, and criticality of life sciences shipments encourage the industry to become a significant adopter of package tracking technologies. Tags that log temperature and communicate the location of shipments in transit are already common. Precise and secure product identification is another priority for healthcare players. The industry has adopted sophisticated serialization strategies, in which primary and/or secondary packaging is marked with unique codes that allow products to be traced back to the original manufacturing batch. Serialization helps in the event of quality problems, allowing non-compliant drugs to be quickly identified and removed from circulation. It also helps companies to combat theft, diversion, and counterfeiting, all common challenges in the sector.

In recent years, DHL Supply Chain and Accenture collaborated on a blockchain-based serialization system to improve quality and compliance in healthcare supply chains. It immutably links shipment information by matching a product with its packaging, location, and condition. Pharmaceutical companies are also adopting a range of other approaches to improve product security, including the use of tamper-evident closures, and

the application of digital watermarks that apply hidden identification information, only readable using specialized equipment.

Changing care patterns

Around the world, people are living longer and choosing to have smaller families. The resultant demographic shift means that by 2050 almost half the world's population will be more than 60 years old, up from 13% today.

To address the challenges of a predominantly elderly global population healthcare providers are exploring new forms of care delivery. They are moving

from standardized treatments and centralized facilities to a world of digitally enabled remote monitoring, personalized medicine, and community or even in-home care delivery.

This has significant implications for medical product packaging. Where local regulations permit, e-pharmacy operations are booming, allowing patients to order their medications online and receive them at home. As in e-commerce more broadly, such services require packaging solutions that can protect the contents throughout a complex, multi-touch logistics chain.

Personalized packaging also provides opportunities to make treatments simpler and more user friendly for patients. US online pharmacy PillPack, for example, helps patients manage complex long-term conditions by packaging multiple pharmaceutical products into boxes or sachets containing the right dose for a specific date and time.



Figure 18



Figure 19

Figure 18: NelumBox is a hybrid packaging solution for temperature-sensitive products during transit and storage. Source: Tec4med Lifescience

Figure 19: NFC-embedded sensors in blister packaging will improve patient compliance and enable real-time treatment monitoring. Source: IMC

The company was purchased by Amazon for \$753 million in 2018, a transaction seen as a first step into the healthcare market by the e-commerce giant, and one that sets a new standard of personalization in the supply chain.

Other players are pursuing smart, IoT-enabled packaging solutions for medical products. IMC's Med-ic system, for example, equips pill blister packs with sensors and a near-field communication (NFC) chip. Via a patient's smartphone, the system can report when pills are removed from the packaging, helping to monitor patient compliance with treatment regimes. This can also trigger an automated repeat order. The company's eCAP product integrates similar functions into a bottle cap for bulk tablets and liquid medicines.

German startup Tec4med has developed a portable medical-grade cooling and heating unit designed to be used for last-mile transportation of sensitive healthcare products, and for storage in the patient's home or hospitals. The NelumBox can maintain the temperature of its contents for up to 48 hours using swappable lithium-ion batteries. It is rechargeable using a normal domestic electricity supply and is best suited for home care and clinical trial logistics (figure 18).



Figure 20: Home delivery of personalized medication caters to the needs of an aging population and requires reliable and secure packaging. Source: PillPack

Figure 20

2.3 RETAIL AND E-COMMERCE – PACKAGING THE STOREFRONT TO YOUR DOORSTEP

For consumer products, our changing shopping habits are driving the largest shift in packaging requirements seen for decades. The rise of e-commerce, combined with the changing role of brick-and-mortar retail outlets, is forcing retailers and consumer goods companies to re-evaluate the role of packaging in product protection, logistics efficiency, and branding and communications.

Moving to omni-channel

Main street stores have suffered at the hands of e-commerce competitors but the internet is still a long way from completely replacing the in-person shopping experience. Instead, modern retail stores are carving out niches as one node in a complex multi-channel retail environment.

Customers expect the same level of service, choice, and convenience from retailers, whether interactions are face-to-face or online. In response, retailers have been investing in omni-channel sales and

fulfillment systems for the past several years. These allow customers to switch freely between channels, browsing and ordering online for pickup in store, for example, or trying products in the shop and then having purchases delivered to their homes.

Omni-channel retail create significant logistics challenges, requiring warehouse storage, pick and pack, and transportation systems to cope with both traditional bulk deliveries to stores and smaller e-commerce shipments of only one or two items.

Many retailers choose to separate some or all of their logistics operations for bulk and e-commerce shipments. No matter how they set up their systems, optimizing packaging and transportation to meet the differing requirements of direct home deliveries, in-store pickup, and conventional store re-stocking remains challenging.

The store as an experience

With e-commerce channels beating traditional shops in product variety and availability, many companies are now asking their stores to perform a new primary role: as a product discovery and taste-making experience for customers.

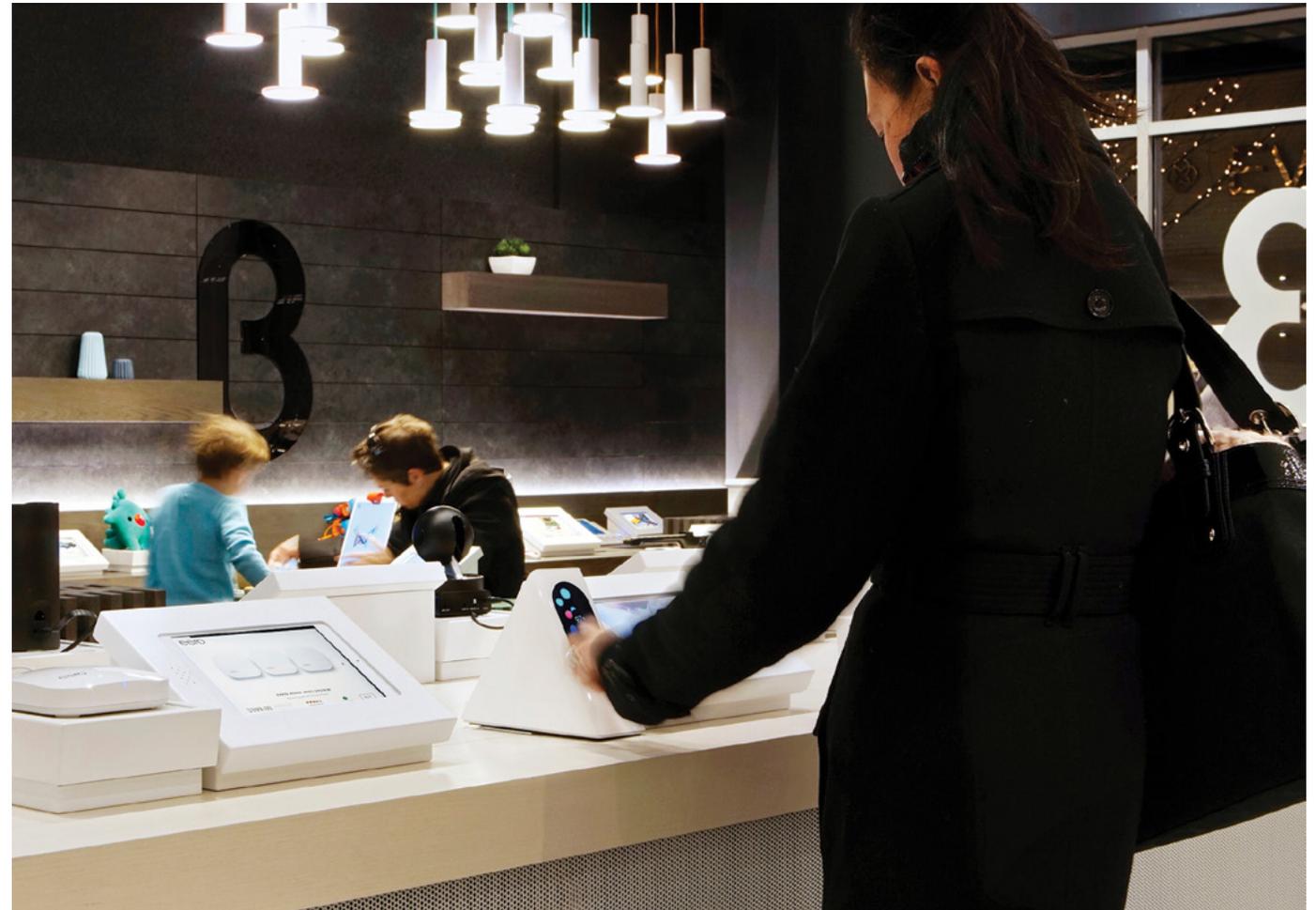


Figure 21

Where retail shopping has traditionally been characterized by boxes and stock on shelves, select retailers are succeeding with minimalistic product displays with little or no packaging in sight.

Figure 21: Experience shopping becomes key in retail as it enables brands to deliver a physical product experience in a more and more digital world.
Source: b8ta

Apple's hugely successful flagship stores have set a new benchmark in the retail industry for the 'store-as-experience' model. Some players are even choosing to outsource the provision of a retail experience to third parties. In the US, for example, b8ta operates a chain of stores (figure 21) that act as a shared retail environment for dozens of brands.

To make the best use of these new retail spaces, brands are changing their packaging designs. Freed from the need to compete for attention on crowded shelves, the new designs prioritize elegant presentation and make it easy for customers to touch and experience the products within. The packaging only comes at the very end of the experience after a purchase, and is designed with the same tasteful intent as the shopping experience that preceded it.

The connected package

Retail packaging is playing a growing role as the gateway between physical products and their associated digital ecosystems. Recognizing the importance of such connections, major brands are investing heavily in the details of packaging design and experience. Some are also using packaging to deliver additional value to their consumers, for example through the



Figure 22

use of QR codes or NFC chips that unlock offers, information, or content on a user's smartphone. New barcodes such as the one from Digimarc even makes those connecting moments seamlessly convenient by invisibly encoding information over the entire packaging surface.

Food and beverage packaging giant Tetra Pak offers its customers a connected

packaging platform which provides a range of digital services accessed via QR codes printed onto cartons. Consumers can scan the codes with their smartphones to access detailed information about each product such as nutritional data, information on provenance, and usage advice. Or the codes can be used to entertain and engage with customers via online games and augmented reality experiences.

For the manufacturer, meanwhile, Tetra Pak's back end systems record scanning events, allowing products to be tracked through the supply chain to the retailer and even into the consumer's home.

From storefront to doorstep

As e-commerce becomes a significant, or even the primary, retail channel for more products, manufacturers are now developing packaging specifically for direct-to-customer shipments.

Many of these new packaging systems are designed to allow products to be shipped without the need for secondary packaging and void fill materials. This cuts costs, reduces waste, and improves the experience for the end customer.

Procter and Gamble now sells Tide liquid detergent in an 'Eco-Box' format, for example. The rectangular cardboard container (figure 23) is safe and efficient to ship, with the highly concentrated detergent sealed in a plastic bag within. Once in the customer's home, the package provides a tap and measuring cup that allows the product to be easily dispensed.



Figure 23

Figure 22: Companies can interact with customers via Tetra Pak packaging before, during, and even after the purchase. Source: Tetra Pak

Figure 23: The Tide detergent container has been reinvented to ensure shipping-safe packaging and customer ease of use. Source: Business Wire



Figure 24

In the UK, Garçon Wines has developed a rectangular, 100% recyclable wine bottle designed to allow unattended delivery through mail slots and letterboxes. Targeted at younger wine lovers living in urban areas, the format allows the safe, space-efficient delivery of a single wine bottle, something that is hard to achieve with the traditional round glass bottle design. Next to that, ten full-sized, flat Letterbox Wine bottles can be shipped in a crate taking up the same space as

four regular round bottles, allowing significantly more bottles to be shipped per pallet.

Viupax is a novel shoe box design that requires around half the material of a conventional rectangular box and takes up half the shipping volume. As a further benefit, especial for younger shoe buyers, the box is designed to be refolded into a toy once the shoes have been removed.



Figure 25

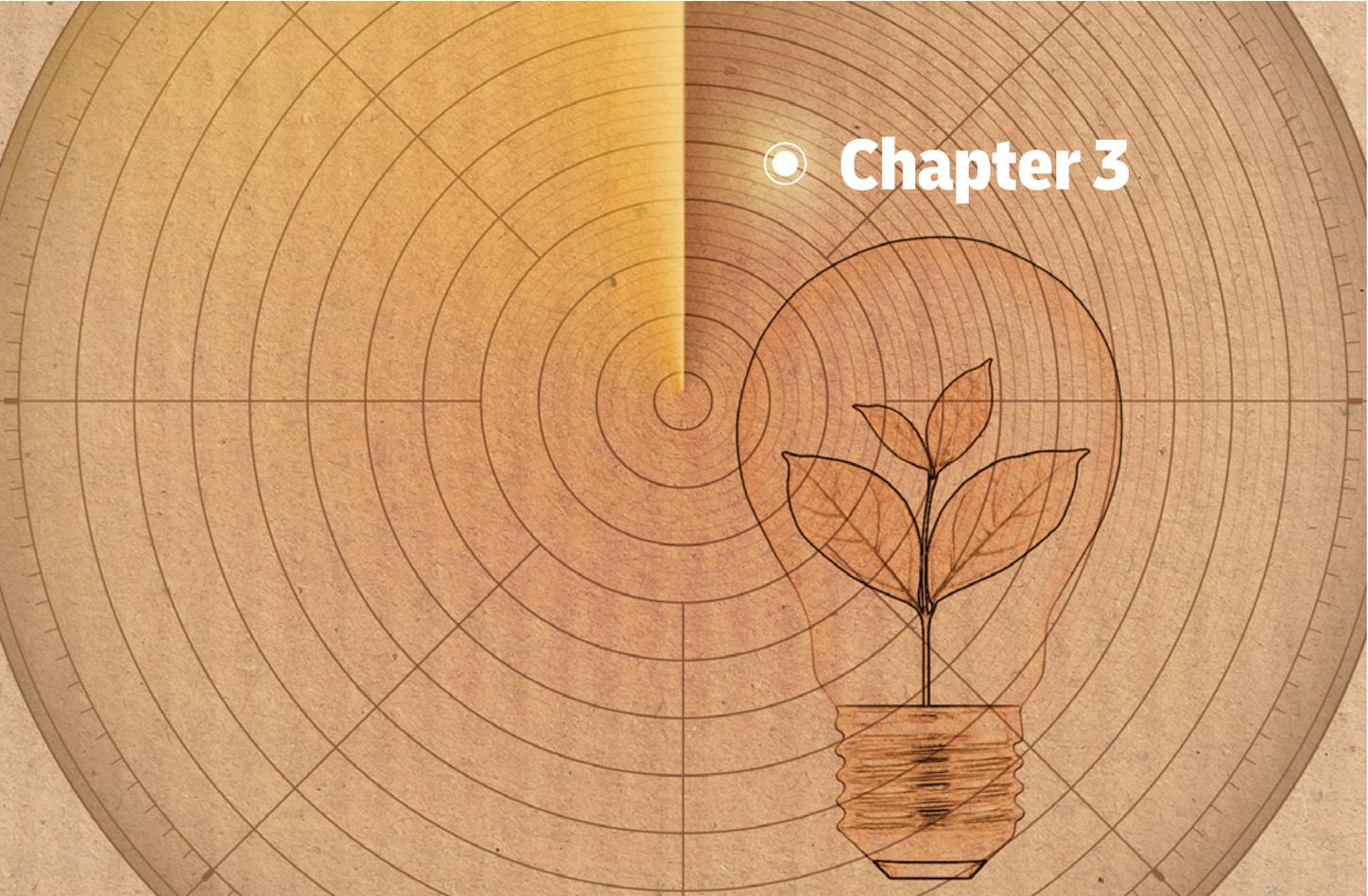
The evolution of e-commerce has encouraged the development of a small number of industry giants. The three largest players – Alibaba, Amazon, and JD.com – control more than 60% of the market. Smaller players haven't been squeezed out, however. Platforms such as Etsy and eBay provide an online storefront for thousands of individuals and small businesses.

Sub-scale e-commerce players find it especially difficult to optimize their packaging operations, as they can't stock numerous different container types. 3M's Scotch Flex & Seal system is aimed at these smaller organizations. It is a self-adhesive protective packaging material supplied on a roll. The user cuts the material to the size needed for each shipment and then presses the edges of the material together to create a durable, lightweight, and space-efficient package.

Figure 24: Letterbox Wine shapes up for the future with redesigned wine bottles – a sustainable packaging alternative with high focus on safety and efficiency.
Source: Garçon Wines

Figure 25: 3M's Scotch easy-to-use protective packaging solution enables quicker and more efficient packing activities for smaller market sellers.
Source: Environmental Leaders

This review of the automotive, technology, life sciences, and consumer sectors provides valuable insight into the packaging needs and priorities of today's supply chain leaders. Clearly, their demands are changing. In the next chapter, we examine the implications for various parts of the logistics industry and investigate some innovative, emerging opportunities to help companies respond to new demands.



Chapter 3

So far in this report, we have examined the major trends that are putting pressure on today's packaging systems. We then looked at the way these pressures are reshaping the demand for packaging in specific sectors.

Now we turn our attention to logistics operations. The logistics industry will play a decisive role in companies' efforts to reduce the cost, inconvenience, and environmental impact of packaging. To achieve those objectives, logistics must adopt new technologies, materials, and processes across the value chain.

In this chapter, we examine key improvement opportunities in five focus areas: packaging optimization, packaging automation, sustainable packaging materials, reusable packaging and reverse logistics, and smart packaging.

● Rethinking packaging for the logistics industry

3.1 PACKAGING OPTIMIZATION

Packaging-related decisions made during warehouse pick-and-pack operations have implications that ripple out across the supply chain. Inefficient packaging, especially sub-optimal fill density, means companies must pay to wrap, ship, and store empty space. Poor package utilization translates into lower utilization of transportation assets, which drives up energy consumption and puts additional strain on network capacity. And under-utilized packaging can also increase the risk of product damage in transit.

Packaging density optimization is an industry-wide challenge. 24% of the volume of the average shipping container is empty space. In some e-commerce categories, parcels contain up to 40% air. The problem is difficult to solve, especially in complex and increasingly fast-moving supply chains where every shipment is different and staff have just a few seconds to plan and execute packing processes.

To improve decision making and to reduce the burden placed on operational personnel, companies are increasingly bringing data and analytics into their efforts to optimize packaging processes.



Figure 26

Building accurate master data

The foundation of all data-driven packaging optimization is a comprehensive digital representation of each SKU. Such data is not always available. In the fast-moving consumer goods industry and the fashion industry, the SKU mix is constantly changing as new product lines and seasonal collections are introduced. In the automotive industry, new product introductions are less frequent but each new model launch can generate thousands of new parts, each of which must be managed through the supply chain.

Recent advances in algorithmic performance and new image processing systems, aided by 3D computer vision and even artificial intelligence powered visual recognition technologies, make it easier for companies to build accurate master data on the dimensions and physical characteristics of each SKU they need to pack.

Computer vision software company Metrilus, for example, has developed a gantry-mounted camera system and associated software that can calculate the dimensions of products or full pallets to within as little as 5 millimeters. Beyond obtaining product weight, dimensions,

and other attributes, the system's software allows warehouse specialists to calculate items per carton, cartons per pallet layer, and the characteristics of a full pallet. They can use this data to plan put-away locations, volumetric picking, and package selection.

Optimizing packaging efficiency and supply chain profitability

Warehouse packing operations today are finding themselves in the middle of a complex optimization problem, constrained by the need to balance carton quantity, fill efficiency, and lower cost. Using a single type of box for every shipment would be the simplest solution from an operational perspective but hugely inefficient in terms of packaging optimization. Using a perfectly sized box for every shipment would solve the efficiency problem, but managing a large quantity of carton types adds cost and complexity to fulfillment operations, and packers may still struggle to make the right choice for each shipment in fast-moving operations.

Determining the optimal number, size, and shape of cartons to balance efficiency and complexity at the lowest total cost is a significant challenge. In e-commerce



Figure 27

environments, the number of standard cartons used by many operations has risen significantly in recent years as companies attempt to find optimum packaging solutions for ever-growing product assortments. Where facilities once relied on 6 to 12 standard cartons, they may now stock up to 25.

Figure 26: Capturing accurate master data on stored SKUs is key to optimizing packing processes and performance. Source: MetriX Freight

Figure 27: The growing number of standard cartons and space limitations in packing areas create operational complexity. Source: Omnipack

DHL's OptiCarton is a new algorithmic optimization tool for warehouse operations. The system uses item-level dimensions and 3D models to identify a minimum number of standard-size cartons required to maximize carton and pallet utilization at a facility. By running the OptiCarton tool periodically as demand patterns and product selections change, companies can maintain high levels of utilization while minimizing the overall complexity of their packaging systems.

Other data-driven solutions attempt to reduce the need for fulfillment staff to make packaging selection decisions. Warehouse management systems (WMS) can use data on the dimensions of products and packaging to make recommendations to pickers about which carton to choose or how to arrange multi-item shipments within a box. While such features have been available commercially for some time, recent advances in algorithmic performance and new paradigms in user interface design are helping to increase adoption.

Similar tools are available to help staff optimize the stacking of parcels onto pallets and the arrangement of cargo in trucks, shipping containers, and airfreight unit load devices (ULDs). Zebra's

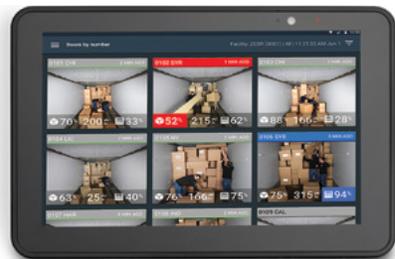


Figure 28

SmartPack Trailer system, for example, is a dock-mounted system that uses a combination of images and 3D scanning technology to identify cartons and then monitor truck loading in real time to guarantee the optimal trailer load down to the individual carton or layer.

While the power of optimization tools continues to improve, the majority of packaging and loading operations are still in most cases performed manually. As a result, the overall performance of the system is determined by the quality of execution by the human operators involved.

Leading players invest significant effort to ensure that their people have the knowledge and capabilities to pack, stack, and load cartons in the appropriate manner to fit pallets, trailers, aircraft bellies, and main deck loads. DHL Express, for example, has developed virtual reality

(VR)-based training aids to help new employees learn how best to load an aircraft ULD. Using gamification elements to engage users, the system helps teams learn how to build optimally dense, regulatory-compliant airfreight loads (figure 29). It also introduces them to the types of exception and challenge they will meet in real-world operations.

In the long term, software-based load planning and optimization systems will provide a commercial opportunity for both truckers and freight forwarders. As the freight forwarding industry continues to move towards online freight marketplaces, transparency in terms of available freight capacity plays an increasingly crucial role for shippers and carriers alike. If shippers can provide more accurate and detailed carton-level information in advance, such as dimensions and images of items to be shipped, carriers can make better decisions on whether to accept shipments. And if those carriers have an accurate, upfront picture of the spare capacity in any given truck, they may be able to use such platforms to make that space available to other customers.



Figure 29

Figure 28: SmartPack Trailer allows real-time monitoring of truck loading processes, creating better visibility and greater load efficiency. Source: Zebra

Figure 29: Using virtual reality glasses during training sessions to sensitize staff for compliant package handling and loading. Source: DHL



“RETHINKING THE WAY WE APPROACH PACKAGING IN THE SUPPLY CHAIN – MAKE IT AN EVERYDAY THOUGHT!”

by **Mark Patterson**, Vice President Global Packaging Solutions, DHL Supply Chain

How many of us pay attention to the packaging each time we unwrap a birthday gift or receive a holiday parcel?

How was it packaged? Did it use recycled materials? Was it damaged during shipment? The simple fact is that whole industries have invested significantly not just in product design but also in packaging design. Taking a closer look, appropriate packaging is all around us with intentional shapes, sizes, and materials to securely store and ship items as diverse as chocolates to home products and spare parts to medical devices.

Where is the greatest need for appropriate packaging? Manufacturing is becoming more costly, and demand planning is more important than ever before. So there is a clear need to make late-stage packaging decisions on quantity, pack size, and promotion further downstream in the supply chain. This adds

flexibility and reduces excess and incorrect inventories. In turn, this allows many operational tasks to be moved into the warehouse, freeing up much needed space in factories.

Our own Packaging Services solution drives significant value and cost savings for customers by aggregating purchase volumes of packaging materials and strengthening inventory and quality controls. Typically our teams go one step further with more efficient and sustainable packaging design to reduce shipped air in the supply chain.

It is critical that environmental impacts are elevated to the forefront of strategic packaging decisions; high priorities for many of our

customers are now the reduction of plastic usage and the move to more reusable materials. We and the entire logistics industry need a firm commitment to promoting, testing, and supporting the introduction of new innovative packaging materials, both at the finished product level and for transit protection. At the heart of our next-generation packaging there must be a shift in how we build packaging, with particular attention to reusability and overall ecological impact.

True collaboration among manufacturers, retailers, suppliers, logistics providers, and end consumers will undoubtedly enable better packaging solutions and, what is more, it will sustain the environment we enjoy today.

3.2 PACKAGING AUTOMATION

Rising demand, an aging workforce, and difficulty recruiting and retaining skilled staff are common themes across the logistics industry. In packaging operations, companies are now addressing these challenges through the introduction of automation.

End-of-line packaging automation

One consequence of the continuing drive for greater speed and convenience in e-commerce has been an increase in the number of single-item shipments. Beyond the common online shopping behavior of making ad-hoc purchases at any given time, one-click solutions, such

as Amazon’s Dash button, trigger an order for a single item with the expectation that it will be picked, packed, and delivered in the shortest possible time. In addition, new subscription services such as Dollar Shave Club, Ipsy in cosmetics, and Outfittery in clothing base their business models on regular, small shipments to customers.



Figure 30

While picking performance has been the traditional focus of warehouse optimization efforts, these large numbers of small shipments mean that packaging operations are becoming a significant bottleneck. That in turn is driving the uptake of end-of-line packaging automation solutions. These solutions create right-size cartons on demand while minimizing packaging material per piece and maximizing protection.

Automated systems use 3D scanning technology to establish the overall dimensions of the item to be shipped. This data is used to cut a right-sized carton and the item is then inserted automatically into the box, along with appropriate documentation, marketing collateral, and other personalization. Finally, the system seals the carton and adds external labeling

and personalization as required (figure 31). Systems from established players such as CMC , Packsize , and new market entrants such as Boxologic promise cost savings and efficiency improvements for shippers. Reducing the consumption of void filler and corrugated materials helps cut freight costs, which is especially beneficial for customers in markets that have adopted dimensional weight billing for freight services.

Figure 30: Subscription services like Outfittery contribute to an increase in single-item shipment volumes. Source: Outfittery



Figure 31

In high-volume environments with high labor costs, packaging automation systems can also help to reduce costs and dramatically increase throughput. Stationary automation systems like these have limited flexibility, however. Most fulfillment operations are likely to need a combination of automated and manual stations to meet the requirements of fast-moving and consistently high-volume shipments, as well as more slow-moving and complex multi-piece shipments which require special handling.

Automation of packing processes

In the retail space, the practice of co-packing items for promotional and seasonal deals is commonplace. Cardboard displays of advent calendars, sun protection creams, and promotions of multiple goods packaged as one at the end of a store aisle are all the result of co-packing that took place somewhere in the upstream supply chain.

Many companies outsource this highly seasonal and labor-intensive activity to specialized service providers that handle packaging activities such as breaking bulk, assembly, labeling, filling, and product packing as well as erecting the displays.

Today, some co-packing specialists are tackling rising demand and shortages of skilled labor by introducing a new generation of collaborative robots (co-bots) from companies such as Universal Robots and Techman to work safely alongside human workers. Robotics applications feature in several co-packing activities. First, the goods are manually de-palletized, sorted, and positioned on a conveyer belt or into a packing unit. Depending on the product or process, the robot then erects the new carton or plastic enclosure, loads products into their appropriate position, and affixes any required labels.



Figure 32

Consumer goods packaging operations are seeing the strongest uptake of co-bots, as the majority of products are well within the 10 kg load capacity of such robots. DHL Supply Chain has pioneered the use of collaborative robots for co-packing, commissioning a central fleet of co-bots between multiple distribution centers, allowing supply chain organizations to handle seasonal and promotional peaks in demand with significantly less friction than having to constantly hire seasonal staff.

Introducing robots that work alongside human operators also helps logistics companies differentiate themselves as employers. Where traditional operations emphasize productivity in manual handling, the ones using robots can keep their employees at the leading edge of a fast-moving area of technology.

Automation of unloading processes

Another side effect of the e-commerce boom is an increase in manual handling. Trucks and containers full of loose cartons are becoming more prevalent in many supply chains, and these must be loaded and unloaded by hand. Repeatedly lifting heavy cartons presents significant injury risk for logistics personnel, and the difficulty of recruiting and retaining staff willing to take on such strenuous work is driving the development of innovative solutions and automated approaches.

Automation company Copal and DHL Supply Chain have pioneered the use of a container unloading system that uses a scanner to locate stacked cartons and an arm with a powerful vacuum gripper to transfer them in sequence to an offload conveyor. The boxes are then transferred automatically to a palletizing cell where they are stacked ready for storage or further distribution.

Today's automated unloading systems can only handle single-size cartons stacked in a structured and orderly manner, but the development of faster, stronger, and more flexible handling technologies may eventually permit the automated handling of chaotically arranged loads of multi-sized cartons in the distant future.



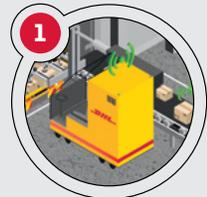
Figure 33

Figure 31: Box-on-demand machines like CMC's boost efficiency in packaging activities while driving significant freight, inventory and material savings. Source: CMC

Figure 32: Co-bots can drive productivity in operations by automating tedious tasks during several stages in co-packing activities. Source: Universal Robots

Figure 33: Copal's container unloading solution drives efficiency by automating the handling of loose loaded goods. Source: Copal

Packaging-related innovations in logistics operations



1 Container unloading automation



2 Reusable packaging solutions



3 End-of-line packaging automation



4 AI-based shipment inspection



5 Truck load density optimization



Figure 34: The introduction of new packaging materials, technologies, and processes has implications for warehouse operations. Source: DHL

Figure 34



Figure 35

AI-driven automated inspection

It isn't just manual tasks that show significant automation potential. A number of solutions under development aim to augment or replace human inspection activities. One key target is the manual completion check of packages prior to sealing. This is a critical quality process, since a single missing item can have a significant impact on customer satisfaction.

Technologies such as Cognex's ViDi deep learning software appear capable in the near future of identifying objects regardless of their orientation and even when they are partially obscured by other items. Using cameras mounted above a moving conveyor belt, and by augmenting machine vision data with other information, such as the overall package weight, these systems can identify incomplete or incorrect shipments rapidly and with a high degree

of accuracy. The same technology can also be used to verify the physical condition of products and packaging, spotting damage, unclear labeling, and other common defects.

Elsewhere, companies are using machine vision and AI to fight fraud and counterfeiting, which is estimated cause \$461 billion in annual losses across global supply chains. Instead of conventional anti-



Figure 36

counterfeit approaches such as tags, chips, and special codes, Veracity Protocol uses computer vision and machine technology to create a unique 'digital fingerprint' of an individual product. The fingerprint is based on very specific features of the product, such as surface texture, making it extremely difficult to fool. End users or supply chain participants can then use a smartphone or other digital imaging device to verify the authenticity of the item they receive.

Figure 35: Advanced deep learning software like Cognex's ViDi can assist in identifying and inspecting shipments to aid handling decisions. Source: Cognex

Figure 36: Veracity Protocol's AI solution creates an immutable digital fingerprint of any physical object. This is used for authenticity and identify verification in reverse logistics. Source: Veracity Protocol

Given that these systems can make a host of decisions on the visual characteristics of packaging in a matter of seconds or less, they offer logistics operators valuable assistance to make better handling decisions.

3.3 SUSTAINABLE PACKAGING MATERIALS



Customers, whether they are e-commerce consumers or B2B customers, are at the frontline in the battle to improve packaging sustainability. Companies face growing pressure to reduce the millions of cardboard boxes and single-use plastic packaging solutions that end up in domestic waste streams and escape into the environment. In our DHL customer survey, the majority of respondents said that introduction of sustainable packaging materials was their number one near-future packaging priority.

Alternative pallet wrap

Plastic shrink wrap is a universal staple of packaging in the logistics industry. The material is cheap, versatile, easy to use, and extremely effective for securing cartons on pallets and protecting packages in transit.



Figure 37

The downside, of course, is waste. The logistics industry currently generates huge quantities of waste plastic shrink wrap, much of which must be managed by customers. Under pressure to reduce the quantity of waste it generates, the industry is exploring a range of alternative solutions.

Recyclable films are one option, but their use depends on the availability of suitable infrastructure. Another is the use of high-efficiency fiber-reinforced stretch films. These provide high levels of protection with less material, reducing both costs and the quantity of waste generated.

Many users would prefer to eliminate the use of films altogether, and companies have developed novel approaches to allow this. Signode Group's LOCK N'POP system uses a water-based 'cohesive' to hold cartons together on a pallet without film, for example.

Other solutions involve re-usable alternatives to plastic film, including pallet lid-and-strap systems such as the Loadhog solution or wraps that can be removed and re-used like the Big Belt solution. Such systems can eliminate waste altogether but their use adds new handling units

to logistics asset pools, which require processes to recover and return them for re-use. Today, this limits their application to predictable, closed-loop supply chains.

Replacing plastic

Resealable plastic envelopes have become the standard packaging solution in many e-commerce categories. Such envelopes have a very short lifespan, however, being used either for a one-way journey from supplier to consumer or a single round-trip if re-sealed and used for the return of a faulty or unwanted product.

Alternatives to virgin plastic for these envelopes and other plastic-based formats include solutions manufactured from post-consumer recycled material or bio-based materials made using starch from sustainable sources such as corn waste, hemp, and seaweed.

Some of these materials are designed to degrade safely in domestic and commercial composting systems. ComPlast, for example, produces compostable bags manufactured from cassava root. The Better Packaging Co produces bags and envelopes made from renewable plant materials, which can be composted at home (figure 38). Paptic manufactures a reusable and bio-based alternative to

plastic which uses wood fiber as its raw material, allowing it to be recycled in waste streams designed for cardboard.



Figure 38

Figure 37: Sustainable alternatives to plastic pallet wrap are being widely introduced in current logistics operations. Source: DHL

Figure 38: Biodegradable, bio-based, and home-compostable plastic alternatives are decreasing the amount of single-use plastic entering the market. Source: The Better Packaging Co

It isn't just plastic bags and envelopes in the sustainability spotlight. Furniture giant IKEA has eliminated Styrofoam from its packaging, replacing it in some cases with mushroom-based biodegradable packaging materials from New York-based Ecovative. German provider Creapaper is using grass rather than wood to produce a low environmental impact fiber suitable for paper and card packaging materials.

The higher cost of these more sustainable solutions has so far limited their large-scale adoption, especially given the extremely low cost of conventional alternatives. While prices are likely to fall in the medium to long term, some companies may stand to benefit from early adoption. Any short-term cost increases could be offset by stronger loyalty from eco-conscious consumers.



Figure 39

Sustainable fresh chain packaging

Online grocery shopping has become a major competitive battleground. In the US, almost half of shoppers now buy groceries online, with highest adoption among millennials. Twenty percent of the US total grocery spend is forecast to move online by 2025, creating a \$100 billion market.

Balancing cost and customer convenience in the grocery sector has proved extremely challenging for the players involved, and companies have experimented with building up dedicated e-commerce fulfillment centers and supplying online orders from existing store networks.



Figure 40



Figure 41

Regardless of the operating model, enabling fast, efficient grocery logistics is not possible without appropriate packaging, specifically when it comes to managing perishability and meeting public health and safety standards. Protecting foodstuffs, especially perishable and temperature-sensitive items, for 24 or 48 hours in a parcel network has historically required climate-controlled trucks and containers. The desire to move away from these high-cost solutions has spurred considerable innovation in the sector.

To maximize sustainability and embrace the circular economy, several players have developed insulating materials made from sustainable materials. Sealed Air's TempGuard, for example, is an insulating paper pad designed to fit inside a cardboard carton. The resulting system



Figure 42

Phase change materials (PCMs) help to keep package contents at a stable temperature by absorbing or releasing heat as they transition between solid and liquid state. While conventional PCMs use oil-based materials, US company Phase Change Energy Solutions has developed a range of bio-based products with performance characteristics that can be tailored to suit freezer, refrigerator, room temperature, and hot food deliveries.

provides good thermal performance in a format compatible with common curbside recycling services.

Easy2cool has developed another recyclable insulation system using cellulose fiber wadding. Woolcool uses sheep's wool wadding sealed in a perforated polythene wrap. Pluumo's sustainable thermal packaging is made from waste feathers generated by the poultry industry, formed into carton liners which can replace expanded polystyrene in temperature-sensitive deliveries.

Figure 39: Ecovative has been the pioneer and leader in manufacturing biodegradable, compostable mushroom-based packaging like their breakaway corners for box-in-box applications. Source: Grow Bio

Figure 40: Recyclable solutions like Sealed Air's TempGuard offer sustainable temperature insulation for pharma and fresh chain products. Source: Sealed Air

Figure 41: Pluumo's sustainable thermal packaging is made from waste feathers. Source: Pluumo

Figure 42: Woolcool insulation is made using 100% pure sheep's wool. Source: Woolcool

3.4 REUSABLE PACKAGING AND REVERSE LOGISTICS



A more sustainable alternative to short-lived plastic or cardboard packaging is the adoption of closed-loop logistics models using durable, multi-trip packaging assets. This approach has been widely used in logistics flows between manufacturing plants, and now a number of players are exploring opportunities to bring this to the consumer space. In DHL's customer survey, the implementation of reusable and circular packaging solutions was the second most important priority identified by respondents.

E-commerce supply chains are already more closed-loop than they may appear at first sight. Return rates of more than 30% are common across the industry, and in sectors such as fast fashion they can reach 60%.

Returnable packaging solutions from companies such as Returnity, LimeLoop, and RePack are now being used in pilots or at commercial scale by a number of forward-thinking retailers.

The returnable mailers developed by these companies are durable, water-resistant pouches, envelopes, and soft folding boxes designed for multiple round trips. RePack has built a unique business model around offering a seamless returns service. A customer can use the bag to send returns back to the supplier or simply fold the bag up and send it back empty through the regular postal system from anywhere in the world.

The first use cases for re-usable mailers have often been subscription services, where customers have regular, repeated interactions with companies. As the concept becomes established, however, it is likely to expand into more conventional e-commerce transactions. Adopting standardized packaging designs would even allow different e-commerce players the potential to share the same packaging pool, further reducing costs, increasing efficiency, and simplifying management activities such as container inspection, cleaning, and repair.



Figure 43

Other providers offer reusable alternatives for specific product types and use cases. Liviri, for example, produces a reusable cold-shipping box for temperature-sensitive and perishable goods, as well as a dedicated cooler for wine shipping.

Working with a healthcare customer in Australia, DHL has developed and implemented a closed-loop box system and two-way logistics process. Orders are directly picked into corflute boxes and delivered to stores, and empty boxes are then reciprocally sent back to the distribution center for re-use.

Building an economically viable reusable packaging system remains challenging in every industry. Key considerations include the required size of the container pool, the design of systems for cleaning, inspecting, and maintaining containers, and the cost,



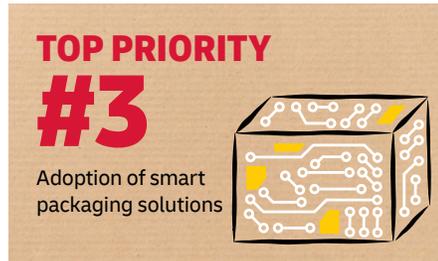
Figure 44

processes. Companies also need to ensure that their end customers are incentivized to send packaging back. To encourage them to do so, some companies operate deposit schemes, discounts for the return of containers, and penalties for non-return.

Figure 43: RePack's pouches can be returned via the regular postal system when empty. Source: RePack

Figure 44: Closed-loop packaging solutions aim to cut waste and carbon emissions by transforming packaging from single-use to multi-use. Source: DHL

3.5 SMART PACKAGING



The growing prevalence of IoT technologies in logistics applications begs an obvious question. When will every package be a ‘smart’ connected package? In DHL’s customer survey, implementation of smart packaging solutions was one of respondents’ top three priorities.

Today, the majority of advanced tags – such as those that sense position, temperature, shock, and humidity – are still only used in high-value shipments. But the cost of such technology is falling rapidly (figure 45). The average price of an industrial IoT sensor has decreased by more than two-thirds since 2004. In the coming years, cheaper hardware, improvements in battery life, and more efficient communication capabilities will extend the range of economically viable IoT applications to include a greater variety of shipment types.

The price of smart package technologies will have to fall significantly further before they achieve anything like universal application, but today’s most advanced technologies provide a glimpse of future possibility. Smart labels like the e-paper display from Faubel are already a viable alternative to paper-based labels for reusable bin and container pools used in pharmaceutical supply chains. And smart labels are more than a labor-saving device for shippers. They can be set to update dynamically during the logistics process, to display the next destination in the supply chain, for example, and to record significant events detected by sensors such as physical shocks and temperature excursions. Finnish IoT company Logmore produces an in-package data logger with an integrated e-ink display. The display generates a dot-matrix QR code which changes at regular intervals as the sensor logs new information. This can be scanned by users with a smartphone to quickly access a report on the conditions experienced by a package in transit.

Smart labels are also moving into the consumer space. German company Inuru, for example, produces self-illuminating labels that use organic light-emitting diode (OLED) technology. The labels light up or animate when activated by touch, motion,

or proximity sensors. Most of the working parts of the system, including the display and the battery, are manufactured using an ink-jet printing process.

Advances in wireless communication technology enable smart tags to communicate from almost any point on a parcel’s journey. Low-power wide area network (LPWAN) technologies can send and receive data over distances of 10 km or more. They are also designed to operate in environments that present difficulties for other radio systems, such as indoor and underground locations. Tags like the one from odyn.ai have also been designed to take advantage of existing public Wi-Fi hotspots.

These technologies provide a low-cost mechanism for tags to communicate relevant events in real time. If a parcel is dropped, damaged, or tampered with in transit, for example, a tag could transmit a warning, allowing the item to be checked or even replaced in the supply chain before the end customer is inconvenienced.

To drive down the cost of smart packaging systems even further, work is underway to eliminate one costly component: the battery. Eliminating the battery from a tag also allows the tag to be made

IoT sensor cost forecast

Falling average cost of sensors bodes well for their adoption on smart packaging

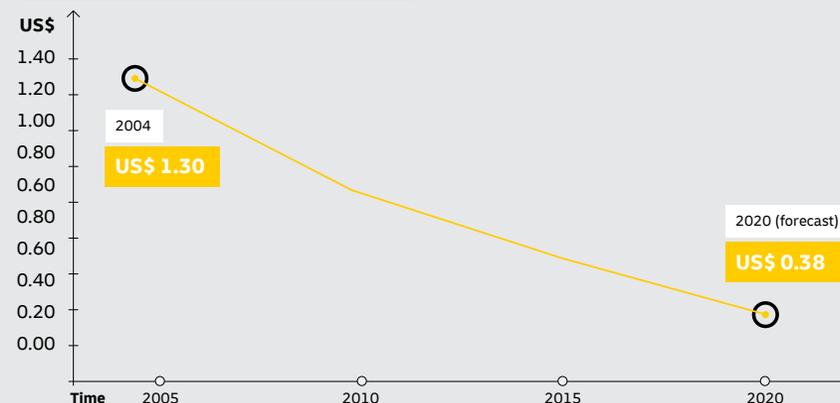


Figure 45

smaller and extends its operating life, which is useful for returnable packaging applications. Battery-free Bluetooth chips from providers such as Wiliot are designed to harvest energy from electromagnetic radiation in the environment. Other systems generate energy from the movement of the packaging in transit or from user actions such as tearing open a specially designed seal.



Figure 46

Figure 45: The falling cost of sensor components opens up new application areas for IoT in the packaging space. Source: Deloitte

Figure 46: Logmore’s QR tags can be easily integrated on secondary packaging, turning them into IoT solutions. Source: Logmore



Figure 47

New businesses based on smart packaging technology are now beginning to emerge, bringing the much anticipated ‘internet of parcels’ a step closer to reality. LivingPackets has launched a foldable smart shipping box for consumer peer-to-peer shipments with a design life of 1,000 journeys. Manufactured mainly from sustainable materials, the box incorporates an integrated load securing

system, an e-ink display to update address data and logistics-relevant information, and sensors and an integrated camera to monitor the shipment contents and environmental conditions (temperature, humidity and shock) during transit. This approach has yet to reach mass market adoption, but it hints at what the future of parcel shipping could entail.



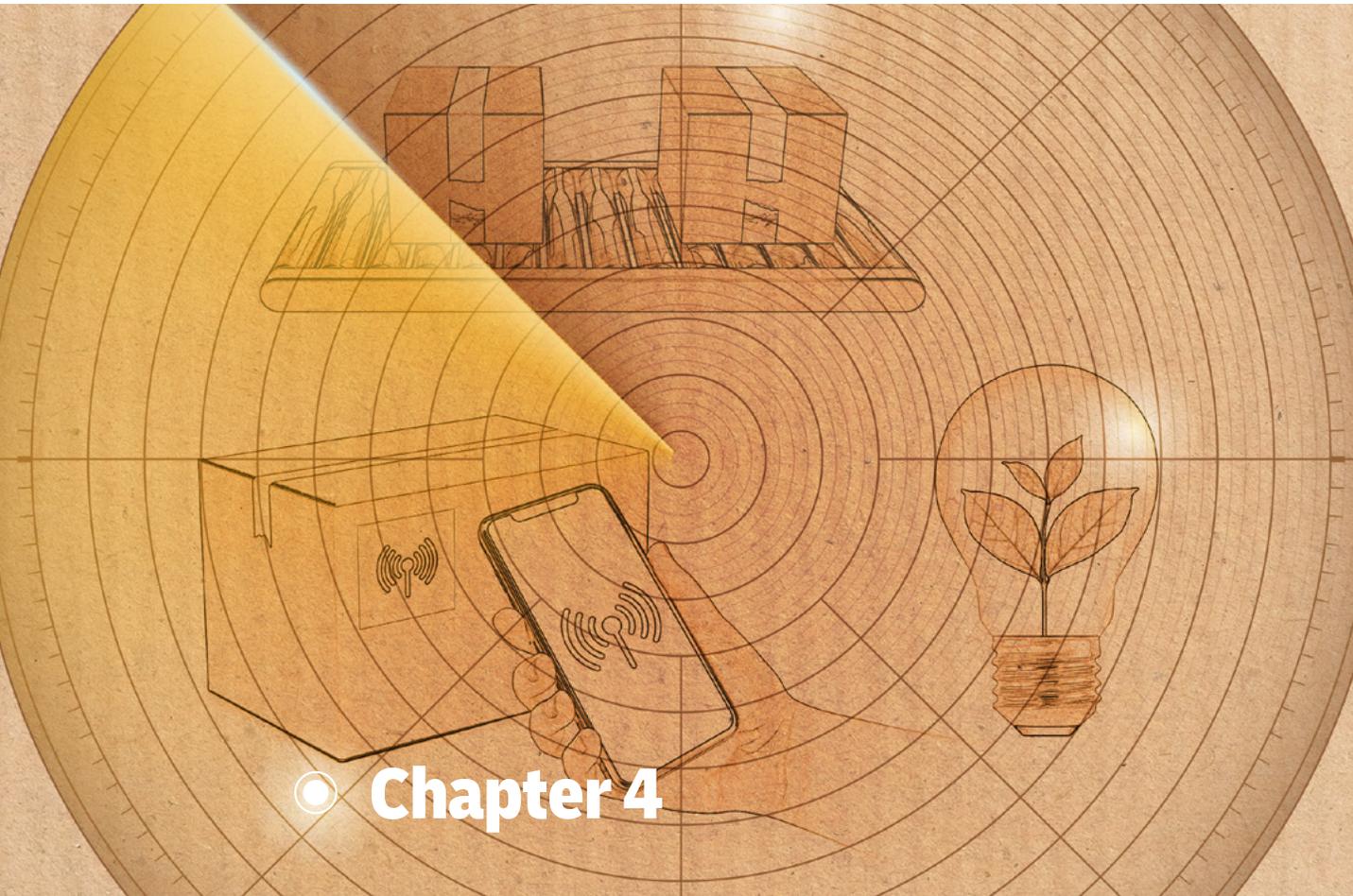
Figure 48

Today, an ‘internet of parcels’ is on the near horizon, catalyzed by falling component costs and a parallel rise in communication technology efficiency and sensor performance. Along with the adoption of new packaging optimization and automation tools, all parties in the supply chain can look forwards to greater efficiency and productivity in logistics operations. In the near future, we will see

the era of single-use packaging coming to an end, replaced by sustainable packaging materials and closed-loop packaging solutions.

Figure 47: A new generation of battery-free sensor tags like the one from Wiliot harvests energy from ambient radio frequencies and will drive further application areas in packaging. Source: Wiliot

Figure 48: LivingPackets has invented THE BOX, a sustainable, secure, and smart packaging solution that can be reused up to 1,000 times. Source: LivingPackets



The world is consuming more packaging than ever before, driven by complex global supply chains and the exponential growth of e-commerce. In trying to balance, cost, operational efficiency, product protection, and user experience, today's packaging solutions all too often come up short. Fortunately, packaging today is becoming a key priority for supply chain leaders, with optimized and automated packing activities, as well as smarter, circular packaging solutions, propelling change towards a more efficient and sustainable future.

Conclusion and outlook

Across industries, increasing demands are being placed on packaging. In the automotive and technology sectors, supply chains must evolve to accommodate growing volumes of delicate, high-value components. In healthcare, logistics professionals must ensure safe and compliant delivery of life-saving medicines and devices to hospitals, communities, and patients' homes. As e-commerce usurps traditional retail, the package on the doorstep is now a critical touchpoint between consumers and brands.

It is little wonder, therefore, that packaging has moved up the agenda of supply chain leaders. There is now unprecedented interest in new packaging materials, new technologies, and new business models.

There are no simple, silver bullet solutions to today's packaging challenges. Instead, companies need to pursue a transformational approach, adapting and rethinking multiple aspects of their supply chain and logistics operations, and considering end-to-end package handling from the factory, into the warehouse, and through the last mile. Companies are likely to adopt approaches as unique as their supply chains, but we believe that certain common themes will emerge.

The first of those is much greater use of data and analytics to support packaging decisions and better balance trade-offs between product protection, usability, and resource consumption. Further improvement opportunities will be unlocked by large-scale adoption of IoT solutions in packaging and this will enable

companies to monitor, understand, and respond to the real-world conditions experienced by their products in transit and storage.

The second big theme is greater levels of automation at every stage of the packaging lifecycle. New automated solutions will enable another optimization step, from on-demand production of right-sized packaging to faster, more efficient personalization, box filling, and handling operations.

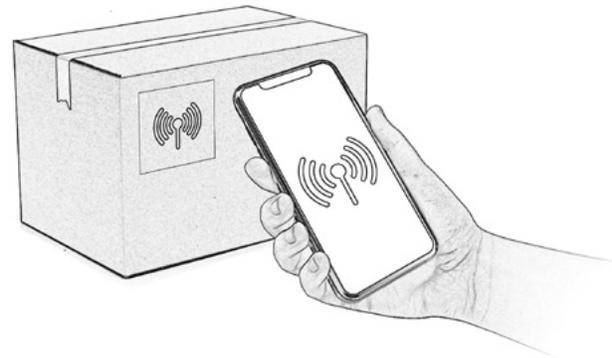
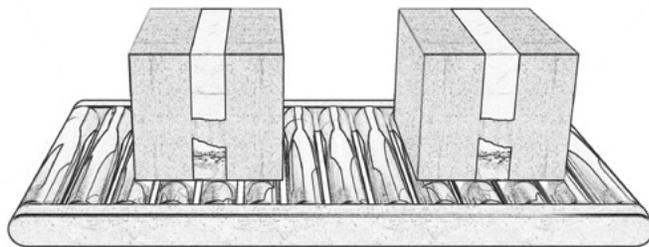
Third, we predict a significant increase in the use of closed-loop or circular packaging concepts, in which containers and materials are returned to their point of origin for re-use or recycling. Already well established in some industrial supply chains, these approaches will move into

the consumer space as people become more sensitive to the environmental impact of single-use products and materials.

Finally, while plastic is likely to retain its position as the primary packaging material for some years to come, sustainable alternatives are inevitable. Companies will face more and more pressure from customers and regulators to develop durable, reliable, cost-effective, easy-to-use environmentally friendly packaging. Achieving those goals will require close collaboration and knowledge sharing between multiple stakeholders, including materials companies, packaging manufacturers, customers, and users, as well as the logistics and waste management industries. It will be essential to jointly rethink packaging, break with the

traditional view of packaging, and move towards treating it as an integral part of the product lifecycle.

At DHL, we believe that packaging is entering an exciting evolutionary phase. We look forward to rethinking packaging with your organization to unlock its full potential. Together we aim to create new value that may have been sitting on the shelf, in the box, on the doorstep, or in your warehouse in plain sight the whole time.



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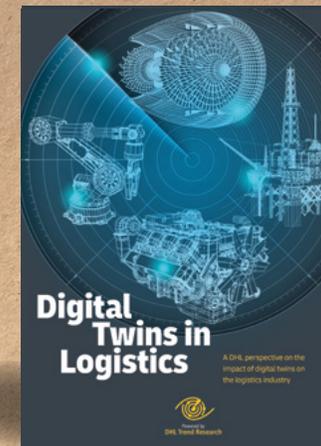
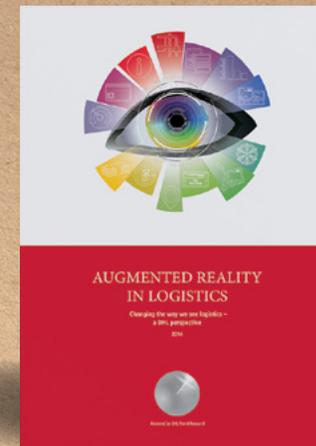
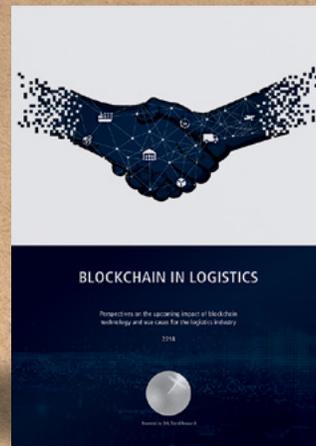
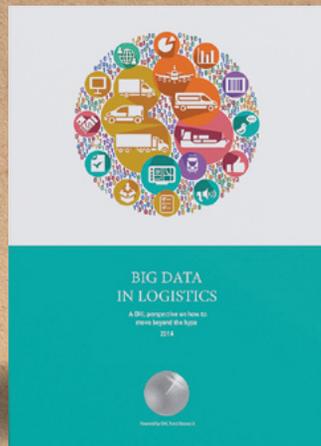
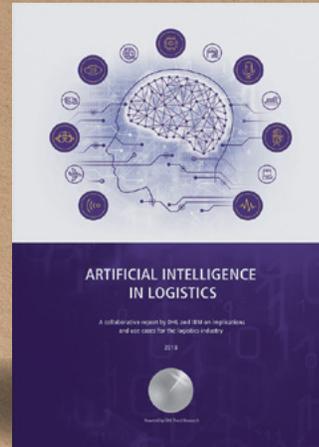
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