



UK Centre for Economic and Environmental Development

Packaging in a Market Economy
A Critical Evaluation of Packaging

**A Report for the Industry Council for Packaging
and the Environment (INCPEN)**



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Foreword by INCPEN

Since its first publication in 1995, this study has remained a vital resource in examining the multifaceted aspects of packaging - functional, environmental, social, and economic. Over the past decades, the landscape of packaging has evolved significantly, driven by advancements in technology, heightened environmental awareness, and changing citizen expectations.

This updated edition continues to emphasise the importance of considering all these aspects at every stage of the product supply chain to make objective assessments of packaging. It also explores the ongoing divergence between the perception and reality of packaging as an environmental issue, a topic that remains as relevant today as it was nearly three decades ago.

UK CEED's independent assessment of packaging for diverse products - ranging from fish to computer monitors, liquid detergents to luxury cosmetics - provides practical guidance on selecting appropriate packaging solutions. These case studies demonstrate the complexities and trade-offs involved in balancing functionality, environmental impact, societal needs, and economic considerations.

True to UK CEED's reputation for balanced and thorough analysis, this report underscores the inherent conflicts and dynamic nature of packaging choices. It acknowledges that the factors influencing these choices are ever-evolving and often in competition.

INCPEN hopes that this updated report will continue to assist companies in making informed, balanced decisions regarding packaging. It also aims to provide clear and factual insights into the pivotal role that packaging plays in modern product supply systems, helping stakeholders navigate the ongoing challenges and innovations in the field.

INCPEN

Preface

This study emerged from the dilemmas I encountered while shopping in Cambridge market, just steps away from our offices. The market offers a variety of stalls selling fresh produce, dairy items, and fish. Nearby, a major food retailer also sells these products. At the market stalls, a fillet of cod might be wrapped in a plain white plastic bag with a piece of sticky tape, and mushrooms are placed in a brown paper bag, deftly closed with a twist by the stall-holder. In contrast, the supermarket offers the same items in sealed plastic containers or wrapped in cling-film, often with outer card sleeves, accompanied by cooking instructions, sell-by dates, nutritional information, and appetising illustrations of what the contents could look like if prepared by someone more adept at using a microwave than myself. Naturally, all this packaging is discarded upon use.

This disparity raised questions for me. Is there something unique about packaging and the packaging market? For instance, when purchasing a car, it doesn't come with an unnecessary extra wheel. Car and tyre manufacturers aren't accused of 'over-wheeling' their product. Is this comparison too simplistic?

Thus, this study was conceived. I am deeply grateful to all those who contributed, especially the staff of the case study companies. Above all, I extend my sincere thanks to Jane Bickerstaffe of INCPEN. It was through my initial discussions with her that INCPEN decided to support our work. Her continuous enthusiasm and advice have been invaluable.

Special thanks also go to the Dulverton Trust for their seed funding, which is part of their broader support for our work at the Centre.

This report was written by UK CEED staff members Jonathan Selwyn and Justine Harbinson. I commend their diligent exploration of the packaging industry's intricacies and the various forms of packaging. This report aims to provide a detailed and clear understanding of topics often debated without such in-depth knowledge.

David Cope Executive Director, UKCEED

Acknowledgements

UK CEED is most grateful to the members of the steering group, Baroness Nicol, Dr Mike Flood and Geoff Hammond, for their valuable guidance during this study, and, in particular, to Jane Bickerstaffe, Technical Director of INCPEN, for her assistance and co-operation throughout the study.

It is not possible to name the case study companies for reasons of commercial confidentiality. However, the authors would like to express their gratitude to the case study companies for their co-operation and to the specialist staff who kindly provided their expertise and assistance during the course of the study.

Jonathan Selwyn

Justine Harbinson

Executive Summary

Introduction

This report explores the critical role packaging plays in a modern product supply system. By examining the entire supply chain, it provides a comprehensive assessment of packaging. Through case studies, the report investigates the processes influencing packaging selection and considers internal and external factors that may lead to excessive or insufficient packaging.

Key Insights

- 1. Over-Packaging Claims:** many over-packaging claims focus solely on environmental or end-use criteria, overlooking the diverse demands on packaging. Such claims often fail to acknowledge the consequences of under-packaging, including resource wastage and environmental impact.
- 2. Complexity of Packaging Choice:** packaging is vital for protection, production, distribution, and storage, while also meeting retail, marketing, and legislative demands. Packaging decisions involve trade-offs between various criteria, such as security measures for tamper-prone products, which may justify additional packaging despite environmental costs.
- 3. Market Incentives:** market forces generally encourage minimising packaging costs. Case studies confirm that packaging supply companies are incentivised to innovate and reduce material usage to stay competitive. Cost considerations drive suppliers to meet client expectations while expanding market share.
- 4. Potential for Over-Packaging:** while minimising costs typically optimises packaging use, market failures can lead to excessive or inadequate packaging. These failures may arise from production constraints, multi-packaging practices, or standardisation requirements that do not fit all product sizes.
- 5. Production and Standardisation:** Production line capabilities significantly impact packaging design. Multi-packaging, often used to test consumer demand, may result in additional packaging. Standardised packaging is efficient for uniform products but may be excessive for varied sizes and mixed loads.

The Role of Information in Distribution

Case study companies conduct extensive in-house testing to assess packaging effectiveness. However, limited data on packaging performance post-production has historically hindered optimal packaging decisions. This trial-and-error approach arises partly because producers have often relied on independent distributors, resulting in limited information flow. Treating distribution costs as overheads further obscures the efficiency of different packaging types. As a result, companies may not always adopt the latest best practices in packaging. Since this report was first written, significant investment has been made in distribution to better understand end-to-end supply chains. This investment aims to optimise these chains, making them more efficient and effective while meeting environmental targets.

Environmental Issues

Environmental considerations, driven by legislation or company policy, are only one aspect of packaging decisions. Focusing narrowly on issues like recycling can lead to inappropriate packaging choices; multiple factors should be considered from the outset of packaging and material choice. For instance, the increased use of recycled materials, while environmentally beneficial, might cost more than virgin materials or require additional outer packaging to protect products, potentially reducing efficiency in distribution and storage.

Such decisions should account for the overall lifecycle impacts of packaging rather than single-issue focuses.

The lifecycle approach ensures that environmental, economic, and functional aspects are all balanced to achieve the most sustainable outcome.

Since the original report, there has been significant progress in encouraging the use of recycled content in packaging. Legislation such as the EU's Circular Economy Action Plan, the UK's HMRC Plastic Tax and various national regulations have set targets for minimum recycled content in packaging materials. These initiatives aim to close the loop on material use and reduce dependency on virgin resources. However, they also pose challenges such as supply chain constraints and quality control of recycled materials.

Companies are now investing in innovative packaging solutions and technologies to meet these new requirements while maintaining product integrity and optimising logistics. The focus has shifted towards a more holistic understanding of packaging's role in the supply chain, recognising that sustainable packaging solutions require a balance between environmental benefits, cost-efficiency, and practical functionality.

Retail Pressures

Large retailers significantly influence packaging choices through their policies, including shelf space allocation based on product size and shape. In the past, this could stifle innovation in packaging design. However, today it is seen more as a challenge for continuous improvement rather than an obstacle to innovation. Supermarkets' inspection of incoming goods has improved, whereas previously, it led to excessive packaging to avoid returns. Although this may exceed other requirements, it can be justified to avoid the costs associated with returned loads.

Misperceptions of Packaging

Criticisms of packaging often stem from misunderstandings of its role in the market system. Packaging facilitates consumer choice, including luxury items and gifts. Judging packaging effectiveness should consider its purpose, including presentation for luxury products, rather than deeming unnecessary packaging as wasteful.

The Role of Marketing

Packaging differentiates products in a competitive market. While product protection is essential, marketing considerations often dominate packaging decisions. For example, a fragrance's marketing image relies heavily on its packaging.

Under-Packaging

Under-packaging can lead to significant economic and environmental consequences, especially in regions with limited access to modern packaging technologies.

Conclusions

Citizen attention on packaging as an environmental issue often leads to an overestimation of its waste contribution. This study highlights that misconceptions about packaging result from a lack of understanding of its purpose and selection processes. Citizen's reliance on packaging efficacy contrasts with their assumptions about superfluous packaging. In a free market, cost drives packaging choices, making excessive packaging economically illogical. However, market failures can still lead to inappropriate packaging.

Policy responses should be fact-based and consider the broader environmental context, ensuring cost-effectiveness and addressing significant concerns. Legislation plays a critical role in shaping packaging practices. Regulations, such as the UK's Plastic Packaging Tax, Extended Producer Responsibility and the EU's Circular Economy Action Plan, aim to reduce packaging waste and encourage the use of recycled materials. While these regulations help drive positive change, they also pose challenges for businesses in terms of compliance and innovation.

Effective policies should strike a balance between environmental benefits, economic viability, and practical functionality. It is essential that legislation is informed by accurate assessments of packaging's impact and considers the entire lifecycle of packaging materials. This holistic approach will ensure that regulatory measures support sustainable packaging solutions without compromising the efficiency and effectiveness of the product supply system.

Introduction

As populations become more affluent, they consume greater quantities of goods, generating waste before, during, and after the use of these goods. This waste contributes to the total waste arising from households, industry, and construction, known as 'controlled waste.' In the UK, waste management practices have evolved significantly since 1995. While landfill was the primary method of waste disposal in the past, there has been a substantial shift towards more sustainable practices.

As of 2025, the UK government has implemented several key initiatives to reduce landfill reliance and promote recycling and reuse. The introduction of the Simpler Recycling legislation aims to streamline recycling processes, reduce contamination, and improve the quality of recyclable materials.

Additionally, the landfill tax has been steadily increasing to discourage landfill use and encourage investment in recycling, composting, and waste-to-energy technologies. The standard rate of the landfill tax in 2025 is £126.15 per tonne of waste. This policy aims to reduce the proportion of waste sent to landfill.

Innovations in recycling technology, such as AI-powered sorting systems and chemical recycling processes, are becoming more widely available, making it easier to recycle materials that were previously difficult to process. The focus on a circular economy encourages businesses to view waste as a resource, promoting the reuse and recycling of materials to reduce waste and save on raw material costs.

Overall, the UK's waste management landscape in 2025 reflects a more sustainable and efficient approach, with a strong emphasis on reducing landfill use, increasing recycling rates, and adopting innovative technologies to manage waste effectively.

The environmental consequences of waste have become a key policy issue. The UK government's sustainable development strategy emphasises minimising waste production and making the best use of the waste generated.

It is suggested that the public pays disproportionate attention to packaging as a component of the UK's waste stream, leading to an overestimation of the proportion of landfilled waste from packaging. This misconception is fuelled by the casual use of the term 'over-packaging.'

An economic perspective on packaging in a competitive supply chain questions the notion of over-packaging. Market forces should encourage minimising production costs, including packaging, to only the necessary amounts to meet product and supply chain demands.

This report examines the role of packaging in the product supply chain using an economic model and specific packaging case studies covering five products. It aims to clarify the demands placed on packaging and the complexity of packaging selection, rather than assessing whether specific products are over-packaged.

The Case Studies

The case study companies were selected based on sectoral issues identified in the initial research. These companies, which have existing relationships with UK CEED, represent chosen sectors and product ranges. While they may be best practice companies, their selection is intended to highlight packaging requirements for a product sector more effectively than companies with limited packaging expertise.

Chapter 1 - Packaging and Packaging Waste

Introduction

This chapter provides an introduction to packaging and waste issues. It examines citizens' perceptions of packaging and its significance as a proportion of total waste generated in the UK.

The Perceptions of Packaging

The basic purpose of packaging is to ensure that a product is delivered to the end user in an acceptable condition. Its environmental consequences relate to the materials used in its manufacture and its disposal after use.

The generally negative image of packaging stems largely from the perception that, because packaging is inevitably discarded after use, it is wasteful and unnecessary. This perception is partly related to the issue of litter. Packaging not disposed of properly can be seen in streets, motorway verges or the countryside, creating a visible environmental impact and reinforcing the idea of 'excessive' packaging.

Citizen attitude surveys indicate that packaging is frequently perceived as 'excessive.' For example, a survey found that a significant proportion of respondents considered products to be over-packaged, citing examples such as multiple layers of packaging or packaging that appears too large or elaborate for the goods contained inside.

However, citizens also recognise the positive aspects of packaging, such as convenience, hygiene, and safety. Even those who are critical of packaging buy packaged goods for these reasons, despite the availability of unpackaged alternatives.

Packaging in the Waste Stream

Accurate figures on the amounts and sources of waste produced in the UK are essential for assessing the importance of packaging in the waste stream. However, data on packaging waste has historically been limited.

Some updated figures for packaging in the waste stream: The UK generated 191.2 million tonnes of total waste in 2020. The recycling rate for packaging waste was 64.8% in 2023. The UK generated 40.4 million tonnes of commercial and industrial (C&I) waste in 2020, with 33.6 million tonnes generated in England in 2022. UK households throw away an estimated 100 billion pieces of plastic packaging annually.

Modern waste management practices have significantly evolved since 1995. The UK has made considerable progress in reducing landfill reliance and promoting recycling and reuse. The introduction of the Simpler Recycling legislation and increased landfill taxes are driving improvements in waste management. Innovations in recycling technology and a focus on a circular economy have also contributed to more sustainable waste management practices.

Summary

- The environmental consequences of waste and the role of packaging in the waste stream have become key policy issues.
- Citizen opinion surveys suggest that packaging is perceived as an important environmental issue.
- The negative image of packaging is largely due to its inevitable disposal and its association with litter, river and ocean pollution.
- Modern data indicates that the contribution of household packaging to total UK waste is relatively small.
- The gap between the perception and reality of packaging as a waste issue is emphasised by the term 'over-packaging,' which has contributed to a negative view of packaging.

Recent Surveys on Packaging Waste:

The Big Plastic Count 2024

Conducted by Greenpeace UK and Everyday Plastic, with academic support from the Revolution Plastics Institute at the University of Portsmouth. Found that UK households discard an estimated 90 billion pieces of plastic packaging annually, with only 17% being recycled domestically. The survey involved nearly 225,000 participants from over 77,000 households, including 28,000 schoolchildren and community groups.

RECOUP UK Plastic Packaging Collection Survey 2024

Conducted by RECOUP, a plastic resource efficiency and recycling charity. Highlighted the challenges and progress in kerbside service provision for plastic packaging. Found that local authorities reported an average material reject rate of 14%, with significant efforts needed to improve citizen communication and reduce contamination.

Chapter 2 - An Economic Model of the Packaging Chain

Introduction

In a competitive market, each actor in the supply chain, from raw materials supplier to retailer, aims to secure inputs (e.g., raw materials, packaging) at the lowest price from suppliers further up the chain. Packaging, as an essential input to many finished goods, is subject to this process. Ideally, in an efficiently operating market, businesses use only the packaging necessary to meet product and supply chain demands.

This chapter examines the role of packaging costs in packaging selection, using an economic model to describe businesses responses to price changes and behaviours within the product supply chain.

What are Economic Models?

Economists use hypothetical models to understand economic choices and their consequences. These models represent simplifications of real-world relationships, providing benchmarks to analyse complex market structures.

Economic models help explain why economies behave as they do, predict future behaviours, and explore how economies can be adapted. In a relatively free market economy like the UK's, individuals and organisations determine the types and quantities of goods produced. The study of these economic choices forms the core of economics.

The Model of Competition

To examine businesses behaviour, economists use models of different market structures. The model most relevant to this study is the 'perfectly' competitive market, characterised by a large number of buyers and sellers trading a uniform good. The market price is determined by supply and demand, with no single supplier able to fix the price. Suppliers and buyers have perfect market information, ensuring uniform pricing.

In this model, packaging suppliers offer identical 'state-of-the-art' packaging, with prices determined by market demand and supply. If a supplier attempts to increase its price, buyers would switch to another supplier offering the lower market price.

The Profit Motive and Minimising Costs

The model assumes businesses strive to maximise profits, defined as the difference between the selling price of the product and the total production costs. To maximise profits, businesses minimise production costs, including packaging costs. In a perfectly competitive market, manufacturers use only the necessary amount of packaging to meet product and supply chain requirements, avoiding additional costs that would decrease profits and competitiveness.

The Model of Monopoly

At the other extreme is pure monopoly, where one business dominates the market as the sole supplier of a product with no close substitutes. Potential competitors are prevented from entering the market due to structural features or restrictive practices.

Monopoly companies may set either the price or the quantity of a good, but not both, as each depends on demand. Like businesses in competitive markets, monopoly companies seek to maximise profits by minimising production costs, including packaging costs. Therefore, they also strive to use the least amount of packaging necessary to ensure maximum profitability.

Other Market Structures

The range of market structures between perfect competition and monopoly is broadly described as imperfect competition. For this report, only the models of perfect competition and monopoly are considered. By examining these extreme examples, it is possible to assess how well real markets, such as the packaging market, perform in practice.

Criticisms of Profit Maximisation Theory

Some economists, such as Galbraith (1967), criticise the assumption that businesses solely aim to maximise profits. They argue that in large organisations, the split between shareholders and managers leads to multiple objectives. Galbraith's model suggests that technocrats in large corporations manipulate demand and negotiate long-term costs, guided by self-interest rather than shareholder interests. This could result in a lack of incentive to minimise packaging costs.

Other economists, like Simon (1947), note that businesses act more like coalitions of different groups with varied objectives, rather than single profit-maximising entities. These groups may include managers, production workers, and researchers. Despite these different motivations, businesses in competitive markets must ultimately maximise profits to survive, as underperforming businesses face challenges in accessing funds and are targets for takeovers.

Market Failures

Economists consider the model of perfect competition as an ideal market structure, resulting in the optimal production and pricing of goods. In such a market, just enough goods are produced to meet consumer demand, and these goods are sold at prices that ensure all goods are consumed while

companies receive adequate returns to stay in the market. However, in situations of productive inefficiency, the wrong quantity of goods is produced at the wrong price. In the context of packaging, this could mean an excessive use of packaging relative to the supply requirements of goods, indicating a market failure (i.e., not achieving the ideal outcome).

Market failures can arise from various imperfections within the market, such as imperfect competition and monopoly, which lead to pricing and output levels that deviate from the ideal outcomes of perfect competition. Incomplete information regarding costs and prices and time lags in adopting new technologies can also cause market failures. Let's explore some of these failures in more detail:

Incomplete Information

Market failures may stem from incomplete information available to buyers and sellers. Without full knowledge of products and prices, market participants might make decisions that lead to higher production costs and prices. In the packaging sector, this could result in suboptimal packaging choices due to manufacturers being unaware of better, lower-cost materials from alternative suppliers.

However, some economists argue that imperfect information should not be considered a market failure. They contend that information itself is not free and should be seen as an additional cost of production. For instance, product manufacturers must balance the costs of acquiring packaging information (e.g., staff time, training) with other production costs. Companies will naturally seek to minimise information-related expenses as part of their overall cost optimisation strategy.

The debate over whether incomplete information constitutes a market failure continues. Nonetheless, the importance of comprehensive packaging information to enable manufacturers to make the best packaging decisions cannot be understated.

Technological Developments

The environmental characteristics of packaging materials are not the primary focus of this discussion. Instead, we are concerned with packaging optimization and not the environmental impacts of material choices.

New packaging technologies that offer cost savings by superseding existing technologies are crucial to these models. While the models present a static snapshot, technological advancements in packaging continue to evolve. Innovations such as lightweighting of beverage containers demonstrate how technological developments can reduce the amounts of packaging used. Changes in packaging technology may also lead to alterations in the form of goods themselves.

The speed with which these new technologies are adopted determines the efficiency of packaging choices

at any given time. Technological breakthroughs take distinct but increasingly shorter periods to diffuse across applications. Thus, at any time, producers may still be using suboptimal approaches. However, market forces that counteract over-packaging will also encourage the rapid adoption of the most efficient packaging methods.

Environmental Costs

Market failures occur when the full costs and benefits of an economic activity are not reflected in a company's profit calculations. Typically, companies base these calculations on the difference between revenue and costs, including land, labour, and capital. However, companies may also utilise the environment during production, such as using land, air, or water to absorb emissions. When companies are not charged for environmental usage (i.e., external costs), they underestimate the true costs of production and produce the wrong quantity of goods.

Packaging costs may not fully reflect environmental consequences associated with selection, use, and disposal, leading to environmental externalities. For instance, packaging costs might not account for air emissions from the factories producing them. Discussions in environmental economics focus on establishing and better reflecting these environmental costs in the markets for goods and services.

This debate is crucial but not central to our study. The degree of packaging and the validity of over-packaging accusations will reflect the market conditions at any given time. Markets may change, and previously external costs may become internalised. Economic theory suggests that internalising formerly external costs could lead to reduced packaging use to lower overall costs. This does not imply previous over-packaging but indicates changing market signals over time.

Other Market Failures

In the real world, blockages to the rapid and universal dissemination of best practices may occur, causing inefficiencies to persist for significant periods. However, there are strong incentives for companies to seek out and eliminate such blockages.

Some examples of sub-optimal practices include:

- Failures in training: individuals responsible may be unaware of opportunities or may lack the skills to seek them out.
- Delays in updating standards and industry-wide norms: this can lead to missed opportunities brought about by technological progress.
- Interference effects: requirements to meet goals unrelated to packaging can create situations where modifying these requirements could reduce the need for packaging.

Chapter 5 investigates the extent to which such circumstances exist in the field of packaging.

The Optimal Packaging Selection

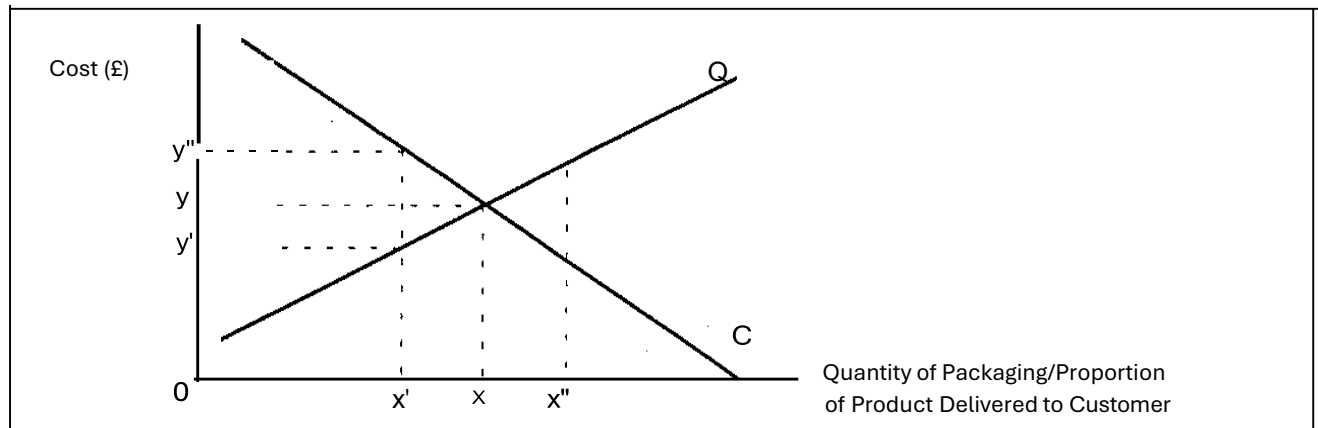
The models discussed earlier have illustrated why companies in the product supply chain have an incentive to minimize their use of packaging. However, the optimal choice of packaging, in terms of cost and its intended function, involves a trade-off.

Figure 1: Trade-Offs Between Packaging Cost and Product Loss

Packaging designed to protect a product from all risks encountered throughout the supply chain would be prohibitively expensive for most goods. Therefore, packaging specifiers implicitly accept a cost/risk trade-off when selecting packaging.

If perfect information were available to the packaging specifier, the optimal use of packaging could be determined based on knowledge of expected loss rates (in monetary terms) and packaging costs. Figure 1 illustrates this concept.

In Figure 1:



The horizontal axis represents the quantity of packaging used and the proportion of products reaching the consumer in an acceptable condition.

The vertical axis represents the costs to the manufacturer, including packaging costs and the costs of product loss (in terms of the proportion of products not reaching the consumer in an acceptable condition).

Curve Q represents the relationship between the quantity of packaging used and its cost, assuming a linear relationship between use and cost. **Curve C** represents the relationship between product loss and the monetary cost to the manufacturer. As fewer products reach the consumer in acceptable condition, the cost to the manufacturer increases. This relationship is shown as a downward-sloping curve—Curve C.

From the diagram, it can be seen that as more packaging is used (represented by Curve Q), fewer products are lost (represented by Curve C). The optimal quantity of packaging is at the point where the two curves intersect (point X on the horizontal axis). At this point, the costs of packaging and product loss are equivalent (point Y on the vertical axis).

If the quantity of packaging were reduced from OX to OX', the cost of increased product loss (represented by the difference between Y and Y'') would be greater than the cost of the packaging saved (represented by the difference between Y and Y').

A decrease in the use of packaging would, therefore, increase the company's overall costs. Conversely, if the quantity of packaging were to be increased from OX to OX'', the additional cost of the packaging would outweigh the cost savings from the reduction in product loss. This, in turn, would increase the company's net costs.

Given perfect information, the specifier would use the quantity of packaging (OX) that equates the cost of packaging with the costs resulting from product loss (OY). This represents the minimum amount of packaging required to satisfy the cost requirements and other demands of the product supply chain.

Summary

Using a simple economic model to describe a business's behaviour in a perfectly competitive or monopolistic market suggests that businesses will seek to maximise profits by minimising production costs. As one of the production costs, manufacturers will have an incentive to reduce packaging costs.

In a situation of productive inefficiency, the 'wrong' quantity of goods is manufactured at the 'wrong' price. When this occurs, the market is said to have 'failed,' meaning it has not achieved an 'ideal' outcome.

In the case of packaging, market failures may result in over-packaging relative to the demands of the product and its supply chain.

The causes of these failures may include:

- Inadequate information flows: Lack of accurate and timely data can lead to inefficient packaging decisions.
- Time lags in adopting new technologies: Delays in implementing innovative packaging solutions can result in sub-optimal packaging choices.
- Failure to incorporate environmental costs: Neglecting the environmental impact in decision-making processes can lead to excessive packaging.

The extent to which markets 'fail' is discussed in detail, with reference to case studies, in Chapter 5.

Chapter 3 - The Purpose of Packaging

Introduction

Packaging for Protection and Purpose Packaging plays an indispensable role in the journey of a product from manufacture to consumption. While cost efficiency has always been a driver in packaging decisions, modern requirements demand a balance between functionality, environmental responsibility, and consumer expectations. Effective packaging not only protects the product but also ensures the sustainability of resources, facilitates production, and supports marketing strategies. It is an integral part of an interconnected supply chain system, fulfilling roles that often go unnoticed by the end user.

This Chapter outlines the demands placed on packaging both by the product itself and also by the processes encountered throughout the product supply chain.

The Demands of the Product

Product Containment Packaging is essential for containing the product, ensuring that all components and accessories remain secure during production, distribution, and storage. Effective containment minimises product loss and safeguards the environment from contamination caused by leaks or spills.

Physical Protection The physical demands placed on packaging are varied and include protection against:

- **Mechanical damage:** Shock, impact, vibration, compression, abrasion, and tearing during manufacturing, distribution, and retail operations.
- **Orientation-specific risks:** Some products require careful orientation to protect fragile elements. This may necessitate instructions printed directly on the packaging (e.g., "This Way Up" labels).

Biological and Chemical Protection Packaging must protect products from biological contaminants (such as bacteria, fungi, or insects) and prevent exposure to environmental factors, including:

- Light, oxygen, moisture, or humidity.
- Chemical reactions, such as corrosion or flavour/odour transfer.
- For food, it preserves nutritional value and quality by slowing natural degradation.

Tamper Evidence and Security Tamper-proof packaging ensures the integrity of the product, offering visible indications of interference. This is particularly crucial for pharmaceuticals, cosmetics, and food, where malicious or accidental contamination can pose significant risks.

Theft Deterrence Design features like blister packs or oversized packaging can help deter theft, especially for small or component-based products. Multi-component products must be packaged in ways that ensure all parts are retained together until purchase. More RFID tags and AI is being incorporated in to the packaging now, either with print or separate labels.

The Demands of Production and Distribution

Machineability and Efficiency Packaging must align with production line requirements, ensuring compatibility with automated systems. The term "machineability" refers to the ease with which packaging is processed, filled, and sealed during production. Poorly designed packaging can disrupt efficiency and increase costs.

Distribution and Storage During transportation and warehousing, packaging must:

- Enable palletisation and support bulk handling systems.
- Withstand environmental conditions, such as freezing or high humidity, particularly for exports to varied climates.
- Protect against damage during stacking or compression in storage facilities.

Traceability and Stock Control Modern supply chains rely on packaging to communicate key information. Barcodes, QR codes, and tracking labels are essential for inventory management, supporting just-in-time delivery systems, and enabling traceability in case of recalls or defects.

The Demands of Retail and Marketing

Shelf Space Optimisation Retailers prioritise packaging that fits efficiently within available shelf, freezer, or cabinet space. The concept of "Direct Product Profitability" (DPP) involves maximising the profit derived from shelf utilisation by standardising

packaging dimensions. The more efficient and effective the packaging is for shelf replenishment the less time, cost and resources are used. Shelf ready packaging that optimises shelf depth and heights can improve availability for the citizen.

Citizen Attraction Packaging is often the first point of interaction between a consumer and a product. Design and graphics has been known to sell a product for the first time and as such, it serves multiple marketing purposes:

- Conveying brand identity and values.
- Highlighting product attributes (e.g., recyclability, premium).
- Creating an emotional connection through aesthetic design, such as vibrant colours or tactile materials.
- Price and promotion attributes (e.g., new product or family sized pack).

Theft Prevention in Retail Retailers often specify packaging that minimises product theft or tampering. Features like tamper-evident seals, secure closures, and bulk packaging for smaller items address these concerns effectively.

Point-of-Sale Enhancements Retailers may add additional layers of packaging, such as gift wrapping, to enhance customer experience or tailor products for specific markets or seasonal events.

Sustainability and Corporate Responsibility

Packaging is increasingly viewed through the lens of its environmental impact. Companies and designers are embracing sustainable practices to:

- Minimise material use while maintaining effectiveness.
- Increase recyclability or reuse.
- Reduce the carbon footprint by sourcing renewable materials or adopting lightweight designs.

Corporate responsibility also extends to adhering to voluntary agreements and meeting environmental regulations. In the UK, for example, packaging Extended Producer Responsibility (pEPR) makes producers accountable for the end to end management of their packaging as placed on the market.

Packaging Failure: Risks and Consequences

Product Damage and Waste When packaging fails, the product may be damaged, deteriorate, or become unsaleable. This is particularly problematic for food, where contamination often results in disposal. The environmental costs are steep, including wasted resources, energy, and labour.

Global Perspective on Food Waste Inadequate packaging and distribution systems continue to contribute significantly to food loss, particularly in developing regions. Recent estimates suggest that up to 40% of food is lost or wasted globally, with much of this occurring along the supply chain due to poor infrastructure, storage, and packaging. In developing regions, food loss is especially pronounced for perishable items like fruits, vegetables, and roots, where inadequate protection leads to spoilage before reaching citizens.

In contrast, developed regions benefit from advanced packaging and distribution systems, which have over time, significantly reduced food loss during transportation and storage. However, food waste at the citizen level remains a challenge, with households still accounting for a substantial portion of waste.

The disparity between regions underscores the critical role of effective packaging in reducing food loss and waste. Improved packaging solutions, particularly in developing regions, could help address global food insecurity and reduce the environmental impact of wasted resources.

Environmental and Economic Costs For non-perishable goods, packaging failure often results in product returns, repairs, or disposal - all of which increase resource consumption, emissions, and waste.

Miscommunication and Overuse Poorly designed packaging that fails to provide clear instructions can lead to misuse or overuse of the product. For instance, ambiguous dosage information may result in waste or inefficiency, or risk to human health.

Primary and Secondary Packaging Roles

Layers of Protection Packaging typically consists of multiple layers:

- **Primary packaging:** Direct contact with the product, ensuring safety and usability (e.g., bottles, trays, cartons).
- **Secondary packaging:** Used for transportation and bulk handling, protecting primary packaging and ensuring ease of distribution (e.g., reusable trays, pallets).

Each layer fulfils specific roles at different stages, from production to retail and ultimately to disposal.

Integrated Systems Packaging operates within a broader supply chain system that has been developed for end to end (E2E) efficiency over the past 30 years. Each stage - production, distribution, retail, and end use - imposes specific requirements. Designers must

optimise packaging to meet all these demands while minimising waste and environmental harm.

Conclusion: Packaging as a Critical Enabler

The choice of packaging influences every stage of the product journey, from production efficiency to citizen satisfaction. Packaging protects products, reduces waste, supports marketing, and enhances usability, all while navigating the challenges of sustainability and regulatory compliance. Its role within the supply chain is indispensable, with success often unnoticed by end users - until failure occurs.

The Demands Placed on Packaging



DEMAND OF THE
PRODUCT



DEMANDS OF
PRODUCTION



DEMANDS OF
DISTRIBUTION AND
DISTRIBUTION



DEMANDS OF RETAIL
AND MARKETING



SUSTAINABILITY AND
CORPORATE
RESPONSIBILITY



DEMANDS OF
CORPORATE POLICY



RISKS AND
CONSEQUENCES



PRIMARY AND
SECONDARY
PACKAGING

Chapter 4 - Packaging Selection and Trade-Offs

Introduction

Packaging is an integral part of the product supply system, enabling manufacturing, transport, storage, and consumption in acceptable condition. While demands on packaging vary at different stages, they are interrelated and must be balanced through trade-offs and compromises. Consumer perception of packaging often overlooks the complex demands of production, distribution, and storage processes.

To assess packaging rationally, we must consider all demands, not just those of the end-user. This chapter uses five case studies to illustrate the trade-offs involved in packaging selection across various sectors: high-value electronic goods, non-food consumer goods, food goods, and cosmetics.

Cost Considerations

Packaging must meet supply chain demands at minimal cost to maximise profitability. However, it must also prevent product loss due to packaging failure. Cost-reduction strategies include material substitution, reduction in packaging material, and design changes. Yet, cost is not the sole determinant of packaging choice.

- **Laundry Products:** A spherical container is cost-effective in primary packaging but inefficient in distribution and end-user usability. Therefore, alternative packaging is used.

Packaging and Product Value

High-value products allow more flexibility in packaging choices since the cost of packaging is a smaller proportion of total production costs, and product protection is crucial, however still must be balanced to not over package and be easy for citizens to recycle.

- **Computers:** High value and low tolerance for product loss justify greater investment in protective packaging. The company aims for extremely low product loss targets, indicating a trade-off between packaging costs and product loss reduction.
- **Fragrances:** Packaging is integral to the product's image, giving designers flexibility in packaging choices, with more emphasis on image than functionality. Many fragrances today offer refills at a discounted price.

For low-value, high-volume products, cost considerations are paramount, with cost savings often sought from packaging.

- **Fish Products:** Lower-cost products like frozen fish fillets use simple - whilst remaining fit for purpose- low-cost polybags, while higher-value products like frozen fish meals use more expensive, image-projected packaging in a variety of formats.

Providing Added Value

Packaging can add value to a product, especially for higher-end items. If the cost of packaging is offset by an increase in sale price and sales volume, it fulfils specific marketing requirements without being superfluous.

Packaging Design and Added Value

- **Fragrances:** Packaging design can add value to a product, whether it's a complex design or a simple yet impactful glass bottle. The case study company uses intricate packaging to position its product in the market.
- **Skin Care Products:** A PET bottle for moisturising cream is designed to look and feel like a glass bottle, adding perceived value by mimicking a more expensive product.

Low-Cost Products and Added Value

- **Laundry Products:** The trend towards concentrated laundry products in smaller packs highlights both environmental benefits and added value. Pack designs like gable top cartons and doy packs improve profitability and market the products as more environmentally friendly.

Effects of Cost Minimisation

Packaging selected solely for cost reduction may fail to meet other demands, leading to product loss.

- **Firelighters:** Reducing packaging for cost savings led to frequent failures, causing inefficiencies and product loss, which offset the initial cost savings.
- **Computers:** Replacing expensive polypropylene cushioning with cheaper polystyrene provided sufficient protection at half the cost, illustrating effective cost reduction without compromising functionality. Many companies have moved towards more sustainable packaging materials for computers that are recyclable and reusable.

Costs Throughout the Product Supply Chain

A comparative analysis of different packaging media costs must consider distribution and storage expenses, impacting the final choice.

- **Laundry Products:** While doy packs and gable top cartons can have a lower unit costs than plastic bottles (volume dependant), they require additional secondary packaging for strength during transit and distribution, making the cost comparison less straightforward.

Product Considerations

Packaging must fulfil multiple roles at different stages of the supply chain, combining product strength and packaging to ensure protection during distribution, storage, retailing, and use.

- **Computers:** Built-in product protection reduces the need for extensive packaging. Laptops are designed for daily transport, require less packaging than desktop machines.

- **Laundry Products:** Packaging for liquids must balance flexibility to withstand impacts and strength to support pallet loads, with additional secondary packaging often necessary.
- **Fish Products:** Variations in fish size and shape impact secondary packaging, this can cause inadequate fill with a potential for cases collapsing during stacking, especially in moist environments.
- **Fragrances:** Dual-function primary packaging protects both the product and its container, emphasising the importance of image and functionality.

Containment and Protection Against Deterioration

Packaging must protect products from physical, biological, or chemical deterioration, ensuring they reach citizens as they have been intended and for the best possible experience.

- **Computers:** Packaging safeguards against physical blows, dust, moisture, temperature extremes, and electrostatic discharge.
- **Laundry Products:** Packaging must contain potentially hazardous chemicals and prevent reactions with the packaging material.
- **Fish Products:** Chilled ready meal packaging prioritises liquid containment, while frozen food packs contain small product pieces, preventing physical, chemical, or biological deterioration.

Protection Against Malicious Actions

- **Fish Products:** In recent years, food manufacturers have increased precautions against tampering with product and packaging. Although frozen fish products are less targeted, the current packaging design and product nature reduce the risk of tampering and contamination. Chilled products also have packaging that makes tampering evident to citizens.
- **Computers:** The bulky size of computer systems deters casual theft from retail outlets, though their high value has seen organised theft during distribution and storage. Packaging must provide a minimum degree of protection against interference, particularly to prevent theft of individual components from within system cartons.

Machinery Considerations

Modern manufacturing facilities represent substantial investments, and production lines must accommodate new packaging designs to maintain efficiency. Any change to a line will incur cost and time, this must be factored into longer term returns on investment to be viable.

- **Laundry Products:** Modifying plastic bottle shapes and designs, particularly height, in many cases allows their use on existing production

lines. However, more significant changes are likely to require a new production line. Additional strength may be needed at the bottle base due to line pressure. The bottle design may also depend on the type of cap, with push-on caps requiring top load strength and screw-on caps needing torsional strength and of course tethered caps now to meet EU regulations. The filling speed for bottles varies with their size, and different lines are required for varying bottle sizes and types, including other packaging formats such as; gable top cartons and doy packs.

- **Fragrances:** Filling and production lines must be flexible, with specially designed pucks (deep trays) for different products. This minimises disruption during changeovers, essential for unique packaging and short production runs. Secondary packaging design must also consider high-speed assembly requirements, the impact of recycled content, and the need for shrink or stretch wrapping to maintain overall strength.

Distribution and Storage Considerations

Packaging design is strongly influenced by distribution and storage requirements, ensuring products move efficiently through the supply chain and reach citizens as they have been intended and in an acceptable condition.

- **Fish Products:** Packaging must withstand conventional handling stresses and specific low-temperature storage and distribution requirements. Moisture resistance is crucial for both primary and secondary packaging, particularly in refrigerated and frozen environments. Some of the packaging for convenience meals must also be able to handle high temperatures post-cooking and low temperatures post-chilling or freezing.

If a product arrives damaged, packaging is often blamed rather than handling or storage methods. A trade-off exists between training staff in distribution operations and the quantity of packaging required for protection.

- **Laundry Products:** Improved training of distribution personnel can reduce product loss, avoiding the need for increased packaging. Enhanced handling and driver awareness have successfully reduced product loss.

Standardisation of Primary Packaging

Modern production systems and cost minimisation drive the development of standardised primary packaging.

Computers: Standardised 'family' of product packaging improves distribution efficiency and reduces new product development time and cost. Packaging graphics, design and labels distinguish between different products. Switching to more standardised packaging with protective 'end caps,' allowing flexibility in the specification of components and accessories.

Palletisation and Standardisation of Secondary Packaging

Automated handling and distribution systems require

standardised pack design and sizing for efficiency. Standardised primary packaging dimensions consider secondary packaging to fit standard pallets, maximising product transport, storage and shelf space.

Computers: Palletised distribution system use modular packs consistent with pallet sizes.

Laundry Products: Efficient distribution of new primary packaging formats relies on quality, standardised secondary packaging. This includes skilful planning of pallets loaded to a height enabling stacking within lorries, considering the strength of packaging.

Fragrances: Unique bottle/atomiser components use additional standardised primary packaging to fit secondary packaging.

Mixed Load Distribution

Market demand changes may lead to less standardised packaging forms, this can potentially reduce packaging per product if handling improves.

Computers: Consideration for flexible distribution systems like cages in trucks and courier services to cope with mixed loads. The use of side clamp trucks are an alternative to fork lifts, though costly.

Retail Considerations

Retailers and large multiples including on line influence packaging specifications in multiple ways, these need to be taken into account as can affect marketing and product presentation.

Retail Environmental Policies:

Retailers may impose environmental guidelines on suppliers, requiring recyclable secondary packaging and closed-loop systems.

Quality Control:

Supermarkets' stringent quality control standards impact packaging specifications for containment, goods in/received to distribution centres, how they are then transported out to stores, and protection.

Fish Products: Retailers prefer lidded frozen ready meal packs for hygiene, this prevents leaking and potential cross contamination to other products despite it being an added costs and can slow down production lines.

Retail Export Constraints

Export markets may require different pack designs for the same product, this can be influenced by retailers' demands or by the information required on pack in the destination country.

- **Laundry Products:** German retailers' have for a long time demanded more efficient secondary packaging to allow for quick product removal this led to a new design with quick-release tabs. These improved designs have translated to other markets, as retailers have looked to improved end to end processes and

reduce resource costs.

- **Fragrances:** Moving towards global packaging standardisation can reduce costs and speed by the increase of automation.

Retail Profit Maximisation

Retailers use Direct Product Profitability (DPP) to maximise shelf space utilisation, influencing packaging design and standardisation. This also influences if a shelf ready tray is to be used or not, the use of shelf ready trays can improve availability as well as decrease the time required for replenishment of the stock on the shelf.

- **Fish Products:** Primary pack size relates to allocated space in chilled and frozen cabinets, reflecting brand leader's packaging. It may also be required as dual merchandising ie landscape or portrait as not all retailers have the same equipment and this can also vary by store size.
- **Laundry Products:** Despite DPP's influence, a variety of designs and sizes are available, across laundry products taking up significant shelf space.

Multi-Packaging

Multi-packaging is a marketing tool that allows individual products or existing multi-packs to be collated into packs using additional packaging such as trays, overwrap, or carrying handles. Most recently a label has been introduced to hold canned seafood together, this has significantly reduced the amount of packaging required. Common products include food (biscuits, crisps, soft drinks, yoghurt) and non-food items (batteries, soap, toiletries, stationary).

Benefits of Multi-Packaging:

- Increased sales for producers
- Compact stacking on shelves and storage areas
- Reduced stock control
- Faster checkout for retailers
- Easier handling of multiple purchases for citizen
- More cost effective to the citizen to buy a multi pack

Implementation: Large retailers initially used multi-packaging to test consumer acceptability of larger quantities, allowing bulk packs or more family sized packs outside of wholesalers. This has been a good way for manufacturers to test the market by collating existing items and multi-packs until demand is confirmed to avoid investing in specialised machinery.

Trade-Offs and Efficiency: The decision to produce multi-packs involves balancing packaging benefits and collation process inflexibilities. Successful multi-packaging can reduce total packaging per product and overall distribution packaging.

Environmental Considerations

Source Reduction: New packaging technologies enable

the reduction of packaging quantities for existing products, supporting corporate environmental policies and cost savings. This includes the development of innovative materials and design improvements that lead to more efficient and sustainable packaging solutions.

- **Computers:** Packaging for keyboards has been downsized by eliminating additional cushioning materials, leading to more efficient distribution. The company has adopted smaller, more compact cartons, optimising space usage during transportation and storage. Furthermore, advancements in material engineering have allowed for thinner yet durable packaging, reducing the overall volume of materials used.

Recycled Packaging Materials: The use of recycled materials is driven by corporate environmental policies and the potential for cost savings. Companies are increasingly incorporating recycled content into their packaging solutions to reduce environmental impact and comply with regulations, such as the Plastic Packaging Tax.

- **Fish Products:** The catering division replaced white kraft cartons with recycled board cartons, initially as part of an environmental policy, which also resulted in cost savings. Although fluctuations in pulp and paper prices affect these savings, using recycled materials helps mitigate cost increases in virgin board prices.
- **Computers:** The switch to recycled pulp material for certain products, such as laptop computers, provides cost advantages, reduces pack sizes, and offers in-house recycling opportunities, complying with export market legislation.
- **Laundry bottle:** packaging has evolved with current trends including the use of higher percentages of recycled plastics, some with closed loop systems and ocean prevented plastics. The development of thinner and more durable bottles, smart packaging with RFID tags and QR codes, refillable and reusable packaging options with refill stations and durable refill bottles, and the shift towards mono material packaging for easier recycling.

Reusable Packaging Materials: Promoting reusable packaging can significantly reduce overall packaging use throughout the supply chain, though it may impact packaging priorities. Reusable containers often lead to cost savings through reduced disposal expenses and support just-in-time delivery systems.

- **Computers:** Reusable packs are encouraged if the increased costs can be offset by reduced disposal expenses for one-trip packaging. For larger products, reusable containers are particularly advantageous due to higher disposal costs of single-use packaging. The company developed an international pallet re-use system, aiming to increase reuse rates for

wooden pallets, despite high costs and durability concerns for alternatives like recycled plastics and cardboard.

- **Fish Products:** Chilled meals are transported in reusable plastic trays returned to the factory after use. This system suits short lead-time products, while frozen products, often stored for longer periods, were initially less suited to reusable trays. As the reusable tray infrastructure has established and there are more reusable trays in circulation, more products have moved to reusable trays.

Recyclable Packaging Materials: Legislation in countries like Germany encourages the use of recyclable materials by penalising non-recyclable materials through levies, incentivising companies to switch to eco-friendly packaging options.

- **Computers:** The transition from composite laminated packaging materials to mono-materials, such as single-material cartons, has not only facilitated recycling but also sped up pack assembly times and enabled bulk consignment deliveries as flat packs or ready-assembled cartons.

International Variations in Environmental Legislation

Packaging legislation across Europe varies significantly from country to country. For example, German legislation focuses on the recyclability of packaging materials, while Switzerland emphasises reducing the volume of waste. These differing policies can lead to conflicting packaging requirements for manufacturers operating in multiple markets.

The Packaging and Packaging Waste Regulation (PPWR) comes into force as of February 11, 2025. The PPWR introduces stricter, standardised rules across all EU member states, aiming to reduce packaging waste and promote sustainability. Key objectives include making all packaging recyclable by 2030, promoting reusable and refillable packaging, and reducing packaging waste by 15% per person by 2040.

Given the PPWR's focus on recyclability and waste reduction, the information provided in the updated section aligns with the new regulations. The PPWR enforces mandatory recyclability, recycled content quotas, and eco modulation fees based on a package's environmental footprint. These measures will significantly impact packaging design, materials, and practices across the industry.

- **Laundry Products:** The company sells into both Swiss and German markets. In Switzerland, easily compactable, thin-walled gable top cartons and doypacks are preferred, although their popularity is declining due to trade pressure for better supermarket shelf space utilisation. In Germany, easily recyclable plastic bottles are dominant since composite packaging like doypacks or gable top cartons is difficult to recycle and would incur financial penalties for manufacturers.

Other Legislative Requirements

Product health and safety legislation significantly influences packaging design, especially for food, pharmaceuticals, and potentially hazardous household products. These products must comply with stringent requirements related to materials, handling, and storage.

- **Food Safety:** The Food Safety Act 1990 (as amended) continues to provide the framework for all food legislation in Great Britain. Chilled food must be kept at or below 8°C from factory to retail, while frozen foods must be maintained at -15°C or colder. This impacts packaging specifications, particularly the need for moisture resistance in cold storage.

Recent updates include the assimilation of EU legislation into UK law following Brexit. As of January 1, 2024, EU legislation retained when the UK exited the EU became assimilated law, ensuring continuity in food safety standards. Additionally, the Windsor Framework, adopted on March 24, 2023, supports the flow of agrifood retail products from Great Britain to Northern Ireland, allowing GB standards for public health in relation to food to apply for pre-packed retail goods moved via the NI Retail Movement Scheme.

These updates ensure that food safety regulations remain robust and aligned with current standards, promoting consumer safety and informed choices.

- **Labelling Requirements:** The Food Information Regulations 2014, which enforce Regulation (EU) No 1169/2011 on the provision of food information to citizens, require that all prepacked food display certain mandatory information. This includes the name of the food, list of ingredients, allergens, net quantity, durability date, storage instructions, usage instructions, and the name and address of the food business operator. Small products may need larger packaging to accommodate this information.
- **Computers:** Outer packaging conveys limited product information, with the bulk of operational details provided in manuals inside the pack. Changes in packaging size to include statutory information may be misinterpreted as over-packaging.

Marketing Considerations

In a competitive market, product marketing is crucial, and packaging often plays a key role. It may be necessary to compromise other packaging demands to meet marketing needs.

- **Laundry Products:** Packaging significantly influences citizen decisions, with products often bought impulsively based on marketing. The design and implementation of doy packs and

gable top cartons has been driven by marketing considerations, despite trade-offs with environmental and distribution factors.

- **Fish Products:** Packaging's role in marketing varies. For competitive markets like frozen ready meals, packaging differentiates products at the point of sale. For conservative markets, such as frozen whole fish, visibility and minimal graphics are prioritised.
- **Fragrances:** Packaging design is dominated by marketing, with first-time buyers attracted by the bottle/atomiser design and image. The marketing demands often outweigh other packaging considerations.
- **Computers:** Traditionally, computer packaging has had a limited marketing role, but the protective quality of the packaging can influence purchase decisions. Today the packaging can be as significant a purchase decision as the computer itself, think about all the work to innovate packaging this sector.

The Changing Market

Changes in market demand for certain products have led to an increased role for packaging in their marketing. This is particularly evident in the computer sector, where the evolving nature of sales has heightened the importance of packaging in marketing products.

- **Computers:** As personal computers have replaced large mainframe systems for commercial use and have increasingly been bought for domestic use, the retail market's importance has grown considerably. Packaging has thus become a marketing issue, especially with the rise of large supermarket-type electronic goods retailing. Products stacked on shelves and visible to customers incentivise computer manufacturers to enhance brand awareness by making their packaging stand out from competitors.
- The focus of packaging's marketing role tends to be on artwork design rather than structural design. When once simple artwork consisting of a single-colour text and logos against a standard brown colour was sufficient, but today's market expects higher end more citizen facing packaging and communication. The surface quality is crucial for good reproduction of complex artwork and design, leading some manufacturers to switch to white coated materials to improve product image. However, such packaging can be susceptible to scratching and visible deterioration, innovation in coatings has reduced this issue.
- The market's changing nature has also meant that, whereas traditionally computer consultants would have set up computers for end-users, most desktop and laptops are now set up by end-users themselves. Their first perception of the product is its packaging, making the packaging's image increasingly important. This is particularly relevant with new packaging materials that may not have the same visual appearance as traditional materials. For high-

value products like computers, it may be necessary to clearly articulate the reasons for choosing a particular packaging material to ensure customer acceptance.

Lifestyle Changes

Changes in lifestyles have led to changes in product and packaging design in particular sectors. For example, the rise in single-person households, eating on the go and increasingly busy lives are particularly evident in the food sector.

- **Fish Products:** The demand for single-portion 'ready meals' and other convenience foods has expanded greatly over the years. Citizens increasingly demand that chilled or frozen foods be cooked in their original packaging, as the ultimate convenience foods. Therefore, packaging for these products must protect them from extremes of cold, heat, and moisture. Despite these conflicting demands, the packaging tends to be fairly simple. It could be argued that if a single person bought all the constituent ingredients separately, the resultant combined packaging and food waste might exceed that of the ready meal.

The Demands of the Consumer

A product received by the end-user in damaged outer packaging may be rejected, whether or not the product itself is damaged. Although the damage may indicate that the packaging has fulfilled its role, a consumer is unlikely to buy a product that appears damaged. As the packaging is usually the most visible part of the product, it must also appear undamaged.

This may lead some manufacturers to specify extra packaging to protect the packaging as well as the product or supply extra cartons for the retailer to repackage the product.

- **Fragrances:** The packaging (e.g., bottle) forms an integral part of the product. Protection of part of the packaging itself is therefore an important overall function. The company uses multiple layers of primary packaging for its products, including an outer carton removed by the retailer before sale. This helps ensure the protection of both the bottle and the highly designed carton surrounding it.
- **Computers:** In this case study the company provides additional empty cartons to retailers and distributors to replace those damaged in transit. This is because citizens are likely to associate damaged cases with damaged products. It is in the company's interest to ensure that the high cost of the product is reflected in the packaging's appearance, preventing the rejection of otherwise undamaged products.

Once a product has successfully reached the end-user, the packaging must facilitate its

consumption. Citizens require packaging that protects a product throughout its useful life and is convenient and easy to use. Packages with pouring spouts, carrying straps, pull-tab closures, resealable features, etc., meet different citizen's needs.

However, some demands placed on packaging at other stages of the product supply chain may adversely affect its suitability for end-use.

- **Pharmaceutical Products:** Packaging must be designed to prevent inappropriate use, for example, by children. However, this may also make the packaging difficult to use for the elderly and disabled.

Similarly, manufacturers are increasingly required to make their products tamper-proof or theft-proof, which may also make their packaging more difficult to open.

The standardisation of packaging to minimise costs may make it less adaptable to new packaging developments designed to improve usability.

- **Laundry Products:** Following their introduction, doypacks and gable top cartons were initially marketed primarily as refill containers for plastic bottles. The case study company's plastic bottles have a standard pouring spout to save on tooling costs.

Originally, spouts were developed before refill containers were widely used, making bottles difficult to refill. However, modern advancements have led to the development of user-friendly refill solutions. Many consumers now prefer refillable options, appreciating both the environmental benefits and the cost savings. Consequently, refill containers have become standalone products in their own right.

- **Aesthetic Expectations:** Citizens often require luxury products to be both high-quality in use and visually attractive. This is especially true for cosmetic and fragrance products, which are often displayed in visible areas such as bathroom shelves or dressing tables. The packaging of such products tends to be highly visible, and citizens' expectations of the packaging can be just as significant as their expectations of the product itself. In today's market, luxury product packaging must not only protect and present the product effectively but also convey a sense of prestige and quality. Citizens are unlikely to purchase a luxury product in packaging that appears 'cheap'.

- **Technology Products:** The issue of packaging perception was highlighted when a company began using recycled pulp material to cushion its portable products. Despite the effectiveness of the material, there were concerns within the marketing department that consumers might perceive the product as being devalued due to the 'cheap-looking' packaging, even though the product itself remained high-quality and expensive. In the current market, eco-friendly materials are more widely accepted and even preferred by many consumers, provided they are presented in a way that aligns with the brand's premium image.

- **Variations in Cosmetic Products:** Not all cosmetic products are subject to the same consumer expectations regarding packaging appearance. For example, the packaging of mascara is less likely to be scrutinised by consumers compared to that of perfume. Mascara is typically not displayed publicly, thus its packaging is less of a concern once purchased. However, eco-conscious consumers today are becoming increasingly aware of sustainable packaging practices across all product categories, creating a demand for both functional and aesthetically pleasing packaging solutions.

The Role of Packaging Suppliers

Packaging supply companies perform a vital function in the product supply system. They ultimately supply product packaging to manufacturing companies, while also developing new packaging materials and technologies and designing packaging applications for various types of products. It is sometimes assumed that the more packaging a supplier can sell, the more profit they can make. However, this is a gross oversimplification of their role.

The primary aims of packaging suppliers are to retain their existing client base and to secure new business. Their customers, on the other hand, seek to minimise costs while meeting various demands placed on packaging, including sustainability and consumer preferences. To maintain their existing client base, suppliers have a constant incentive to drive down unit packaging costs by developing new and improved forms of packaging that appeal to their customers.

Innovation in Pack Design by suppliers often involves developing new materials or processes that reduce the quantity of packaging required. Such developments are particularly attractive to manufacturing companies. Successful packaging suppliers are more likely to encourage reduced levels of packaging for a particular product, which not only attracts customers but also provides added value with increased profitability per packaging unit.

Supplier Relationships and Innovation, a product manufacturing company's packaging specifier has the choice of either maintaining a small number of preferred suppliers to work in partnership on packaging development or determining their own packaging specifications and letting suppliers compete through a tendering process. While the latter may minimise costs, it could hinder innovation due to limited cross-fertilisation of ideas.

By innovating, suppliers can maintain good relations with producers, which wield significant market influence. Close cooperation enables

suppliers to develop their own capabilities and knowledge of the product sector, giving them a competitive advantage, especially with future product strategies.

Industry-Specific Examples

- **Computers:** Companies responsible for supplying computer packaging materials play a crucial role in developing new and existing packaging technology. The shift from traditional tendering processes to a partnership approach has facilitated closer working relationships and active cooperation at all stages of product design and production. Suppliers now have an incentive to innovate packaging specifications and designs to maintain and expand their market share.
- **Fish Products:** The company's relationship with its packaging suppliers is one of 'partnership in problem-solving.' New packaging technology often comes from suppliers, either by buying in technical expertise or through innovation. For example, the switch from 'CPET' trays to 'dual-ovenable' board trays for frozen fish ready meals was a result of the supplier being challenged to match the profile and handling convenience of traditional CPET dishes. The supplier created board trays with the desired appearance, capacity, and handling performance.
- **Laundry Products:** Many new packaging designs for liquid laundry products, such as doypacks and gable top cartons, were first developed by packaging suppliers in-house and later adopted by the packaging departments of major companies.

Technological Development

The adoption of the latest packaging technologies depends critically on the desire and capability of the packaging specifier to assimilate information within given budgetary constraints. The specifier must be both aware of and receptive to new developments, and the budget must allow their implementation if required. Efficient dissemination of information is vital to minimise the time lag between the development of a new packaging product and its implementation to market.

Where information is rapidly assimilated by the specifier and translated into new developments, it can lead to significant advances in packaging specifications. However, as noted in previous sections, information is not a costless resource and must be traded off against other packaging requirements.

Technological Advancements in Packaging

- **Fish Products:** All packaging suppliers are required to adhere to comprehensive specification guides, updated in response to new developments in technology and changes in the company's packaging policy. The

introduction of coated boards suitable for conventional and microwave ovens has greatly increased the convenience of frozen and chilled ready meals, providing significant benefits to the final consumer.

- **Computers:** The company provides a comprehensive packaging specification manual to its suppliers, detailing acceptable materials, usage requirements, compression values, inks, colours, and print designs. All packaging media used must conform to health and safety, environmental, product protection, and distribution standards. The manual serves as a guideline rather than a mandate, allowing packaging specifiers the freedom to innovate.

The manual, updated every two years, to provide online information to all users worldwide. This system allows for rapid updates in light of new developments in the packaging sector. Packaging departments feed their own information into the system, enabling immediate responses to new information, rapid adaptation of packaging, and internal benchmarking.

In addition to internal benchmarking, the company compares its packaging to that of competing companies and other product sectors, feeding the results back into the information network. Other sources of external information include exhibitions, demonstrations, and trade journals.

Summary

The case studies illustrate that packaging selection is dependent not on discrete choices made in isolation but on numerous complex trade-offs and compromises among different supply chain demands. Key considerations include:

- **Cost Considerations:** Designing packaging to protect a product against all eventualities would be prohibitively expensive. Therefore, a trade-off is made between the quantity of packaging used and an acceptable loss rate for the product.
- **Machinery Considerations:** A production line in a modern manufacturing facility represents a substantial capital investment. Therefore, packaging must be chosen with consideration of production processes, which may conflict with other packaging objectives, such as the rapid adoption of new materials.
- **Distribution and Storage Considerations:** The way a product is transported and stored significantly influences the choice of packaging material and its overall design.

Other demands, such as cost or environmental considerations, may compromise its distribution and storage effectiveness.

- **Retail Considerations:** Retail environmental policies and practices, such as Direct Product Profitability (DPP), may constrain packaging selection. Retailers promote the use of recycled/recyclable materials while encouraging standardised forms of primary packaging.
- **Environmental Considerations:** Packaging selected primarily based on environmental criteria may fail to meet other objectives. For example, easily recyclable materials like glass may be heavier than alternatives like laminates, impacting distribution efficiency. Trade-offs may also be necessary between environmental and non-environmental requirements, such as increasing packaging quantity in response to theft or interference, which may conflict with objectives like source reduction and recycling.
- **Legislative Requirements:** The desire to minimise packaging may be hindered by statutory information requirements. For example, packaging for pharmaceutical products may need to be enlarged to carry necessary health and safety information.
- **Marketing Considerations:** Packaging plays a crucial role in product marketing, necessitating compromises in other objectives. For example, new laundry packaging designs have been influenced by marketing considerations, even though their distribution efficiency may be relatively poor.
- **Consumer Demands:** Consumers require packaging that protects a product throughout its useful life and is convenient and easy to use. Their expectations may lead them to assume that any packaging beyond what is needed for final consumption is superfluous.
- **Role of Packaging Suppliers:** To maintain and expand their client base, packaging suppliers have a constant incentive to innovate and drive down unit packaging costs. Successful suppliers are likely to encourage reduced levels of packaging rather than promoting over-packaging.

To assess whether a product is over-packaged, it is vital to consider the role packaging plays throughout the product supply chain, not just at its end use.

Chapter 5 - The Potential for Over-Packaging

Introduction

Chapter 4 highlights that the final packaging selection involves trade-offs influenced by a company's production processes, distribution and storage systems, marketing priorities, retailer relationships, environmental regulations, and product safety legislation. The resulting packaging is a compromise between these competing demands.

Despite inherent compromises, Chapter 2 indicates that competitive supply chains incentivise companies to minimise production costs, including packaging costs. Cost minimisation is a major driver for packaging reduction, as observed in case study companies, which devote significant resources to developing suitable packaging.

However, evidence from case studies shows the potential for selecting 'wrong' packaging in some operations. Market failures, noted in Chapter 2, prevent efficient market functioning. This chapter assesses areas where the packaging market might fail, leading to 'over-' or 'under-packaging,' and examines production, distribution, retailing, and marketing for evidence of these failures.

Production and Distribution:

Company and Packaging Chain Structures

Company Structures and Information Flows: Large multinational companies often have complex structures, managed either centrally or decentralised. Efficient internal and external information flows are crucial for performance and decision-making. Inadequate information can lead to inefficiencies, impacting financial performance and market sector health.

Digital Transformation and Smart Packaging:

Artificial Intelligence (AI): AI-driven packaging design enhances product personalisation and efficiency.

Internet of Packaging (IoP): Connected platforms and smart labels enable real-time tracking and consumer interaction.

Robotics and Automation: Advanced robotics and automation improve production quality and efficiency.

Blockchain Technology: Ensures transparency and traceability in the packaging supply chain.

Sustainability and Eco-Friendly Materials:

Biodegradable and Compostable Materials: Innovations like mushroom-based foam and seaweed plastics offer sustainable alternatives.

Lightweight Packaging: Reduced material usage without sacrificing strength or protection.

Circular Economy: Emphasis on recycling, reusing, and reducing waste throughout the packaging lifecycle.

Extended Producer Responsibility (EPR): Regulations mandate plastic reduction and recycling targets, with companies accountable for post-consumer waste management.

Information Failures Observed in Case Studies:

Internal Accounting Practices: Internal accounting often obscures distribution efficiency of packaging. Distribution costs, treated as general overheads, are not broken down for individual products, hiding the costs of inefficient packaging designs.

Example: Laundry products case study showed different primary pack designs with varying distribution efficiencies, yet costs were not accounted for individually.

Wastage Rates and Monitoring: Knowledge of product loss is essential for optimal packaging. Limited monitoring of in-use performance hampers analysis of packaging effectiveness.

Reliance on independent distribution companies restricts information flow.

- Example: Case studies revealed that significant information was only provided after major product losses, hindering effective packaging selection.

Knowledge of Packaging Developments: Packaging technologies develop at a fast rate, but it is challenging to keep up-to-date. Limited information can lead to sub-optimal packaging choices. Market forces encourage rapid deployment of efficient packaging, yet producers might use outdated methods. Case studies showed best practices in packaging design and development, with no evident issues in keeping up with technological advancements.

Standardised Packaging (Updated for 2025)

Most large manufacturers use bulk distribution systems, requiring standardised secondary packaging. Many also use standardised primary packaging, which may not suit all products. Standardisation works well for uniform products shipped in bulk but less so for varied sizes and shapes, leading to inefficient packaging.

Examples of Inefficiencies:

- **Fish Products:** Vary in size and weight, requiring large enough packaging for the largest portions. Standard-sized cartons can lead to empty space for smaller portions, while polybags are more flexible but may not meet marketing needs.
- **Fragrance Packaging:** Diverse packaging leads to varying 'headspace.' The case study company uses reusable packing materials to fill this space.
- **Mail-Order Sales:** Standardised dispatch packaging for customised orders can lead to excessive packaging for some products.

Products Made to Order: Custom-made products, like computers, may bypass standard distribution systems, leading to non-optimal packaging in standard cartons.

Standardisation for Export Requirements: Different countries' import regulations may require specific packaging, leading to non-optimal specifications in other markets if standards are duplicated.

Environmental Policy: Legislation focused on recycling often ignores upstream implications, potentially achieving the opposite of intended goals. Companies' environmental policies tend to follow this narrow focus.

Promotion of Recyclable Packaging Materials: German legislation penalises non-recyclable materials, like laminated foils, leading to increased transport requirements if companies switch to heavier alternatives like glass jars.

Source Reduction and Lightweighting: Pressure to reduce packaging results in cost benefits but can weaken pack strength and integrity. Lightweighting in plastic bottles led to issues with capping, labelling, and bulging, causing difficulties in label adhesion and reduced resistance to atmospheric conditions. These problems can be managed through in-mould-labelling (IML) and 'puck' support during the filling process.

Trade-offs in Source Reduction: Reducing primary pack weight may necessitate larger secondary packs, reducing distribution and storage efficiency. High recycled content in secondary packaging can exacerbate these issues, requiring stronger primary packaging or additional protective layers.

Retail Considerations

Retail Sector Domination: Large multiple outlets dominate the retail sector, particularly in the food and non-food household goods sectors. Supermarkets' substantial buying power significantly influences suppliers' products and packaging.

Direct Product Profitability (DPP): Retailers have been known to set shelf space according to the brand leader's size and shape, discouraging packaging innovation and encouraging standardisation. Non-conforming primary packs may be penalised,

incentivising packaging specifiers to follow the brand leader's design.

Delivery Procedures: Just-in-time delivery procedures at larger supermarkets minimise storage space and maximise sales area. Orders are placed when shelf stock is low, and products are placed directly on shelves from the lorry deliveries. Packaging failure may lead to entire lorry returns, prompting conservative packaging specifications to avoid such issues.

Multi-Packaging: Multi-packaging has benefits but is constrained by existing processes. Collations of existing packs with layers of overwrap and trays can increase packaging per product.

Example: The Packaging Standards Council (1995) received complaints about multi-packs of chocolate snack biscuits due to excessive overwrap layers. Potential reduction in primary collation wrapping could be up to 60%, representing about 3gms of wrapping per multi-pack with an estimated value of about 0.7p.

And more recently, modern beverage multi-packs often use plastic rings or shrink-wrap, which can lead to excessive packaging. Innovations like biodegradable rings and minimalistic cardboard carriers are being explored to reduce waste. In addition to this: Multi-packs of cleaning supplies often use large plastic containers to bundle smaller items, leading to increased plastic usage. Companies are now exploring reusable and refillable packaging solutions to minimise waste

Marketing: Marketing is often cited as a cause of over-packaging. Critics argue that marketing-related packaging is unnecessary, but this view ignores market system realities.

Summary: Case studies show that complexities in packaging selection and market inefficiencies can lead to excessive or insufficient packaging. Potential market failures were observed in production, distribution, environmental policy, and retail.

Key Points:

Information inertia prevents rapid adoption of new packaging, resulting in outdated practices.

Distribution costs treated as overheads obscure the efficiency of different packaging designs.

Deficiencies in monitoring in-use packaging performance and product loss rates exacerbate information failures.

Standardised secondary and primary packaging restrict flexibility, leading to inappropriate packaging for variable-sized products.

Narrow environmental policies focusing on recycling may unintentionally increase packaging quantity.

Retailers' policies, including DPP, stymie packaging innovation and lead to conservative specifications.

High installation costs for new production lines deter rapid introduction of new packaging technology.

Chapter 6 - Conclusions

Introduction

The public often overestimates packaging's environmental impact, leading to misconceptions about over-packaging. This study highlights that such views stem from a lack of understanding of packaging purposes and selection processes.

Citizen Awareness

Citizens are generally unaware of the upstream role of packaging and the complexities in its selection. While they may see some packaging as superfluous, they rely on its effectiveness for product purchase decisions. In a free market, producers aim to minimise costs, including packaging, making excessive packaging economically illogical.

Market Failures

Some claims of excessive packaging are valid. Case studies show market failures can lead to both over- and under-packaging. Citizen choices significantly influence a company's response to these market failures.

Citizen Choice

A free market thrives on citizen choice. Packaging criticisms often overlook its role in providing this choice and are, in effect, critiques of market operations and consumer lifestyles. For instance, pre-sorted, packaged products offer convenience and uniform quality, catering to specific consumer demands.

Example: The case study of the food products sector highlighted that pre-sorted, packaged fresh/chilled products provide convenience and may offer more uniform quality and longer shelf life than loose produce. Citizens often pay a premium for these benefits, which some environmental groups misinterpret as the cost of over-packaging, ignoring the economic rationale.

Marketing's Role

Marketing differentiates products and encourages consumption. Packaging plays a crucial role in this, especially for products like fragrances. While some view marketing-related packaging as excessive, it reflects market realities and consumer demand. Companies may resist new packaging materials and designs to maintain established product images.

Example: In the fragrance industry, packaging is integral to the product's marketing image. Changes in packaging could dilute the brand, so companies may avoid adopting new materials or designs despite environmental benefits.

Environmental and Non-Environmental Trade-Offs

Packaging choices often involve trade-offs. For example, products needing extra security to prevent theft may require additional packaging, justified by the need to prevent product interference.

Example: A product susceptible to theft may need tamper-evident packaging, which consumes more resources but prevents criminal activity and associated costs to society.

Packaging Standardisation

Standardisation can lead to over-packaging for certain products. However, it also offers cost and efficiency benefits throughout the packaging chain. Using existing designs is often more cost-effective than creating new ones, balancing the potential for over-packaging with overall efficiency.

Example: Standardisation simplifies logistics and reduces costs, though it may not be suitable for products with varying sizes and shapes, like fish products or fragrance packaging, leading to inefficiencies.

The Packaging of Luxury Products

Luxury Consumption

In a free market, consumption extends beyond basic survival needs to include luxury items. These items, often given as gifts or consumed for pleasure, place significant emphasis on presentation. For luxury goods like perfumes and cosmetics, packaging plays a crucial role in presentation and may even be enhanced by the purchaser.

Environmental Trade-Offs

Luxury packaging involves an environmental trade-off, consuming resources to meet presentational requirements. Criticisms of such packaging often reflect criticisms of the product

itself, as the packaging serves its intended purpose.

Implications for Policy

Market imperfections can lead to over-packaging, but expecting companies to always choose the 'optimal' packaging is unrealistic. The profit motive generally drives companies to minimise packaging costs. When poor packaging choices occur, it's essential to examine whether they stem from ignorance or broader market failures.

Policy Makers' Role

Packaging legislation often responds to public concern about waste but may lack understanding of packaging's role in product supply and wider environmental consequences. Policies focused narrowly on recycling may neglect other important options.

Policy Recommendations

- **Fact-Based Policy:** Packaging policy should be based on accurate assessments of excessive packaging and its relative importance compared to other waste.
- **Understanding Market Dynamics:** Recognise the inherent market imperfections and the economic incentives driving packaging decisions.
- **Balanced Approach:** Consider both environmental and non-environmental criteria in policy-making to address the complexities of packaging decisions effectively.

Introduction to the Appendices

The case study companies were selected based on sector-specific issues identified during initial research. Assessing different sectors and products allowed for a comprehensive examination of the demands and trade-offs in the product supply chain.

Sectors Chosen:

1. **High-Value Electronic Goods:** Appendix 1
2. **Non-Food Consumer Goods:** Appendix 2
3. **Food Goods:** Appendix 3
4. **Cosmetics:** Appendices 4a and 4b

Each sector had one or more products selected for in-depth analysis. Companies chosen had existing relationships with UK GEED and closely represented the selected sectors and product ranges. UK GEED believes that best practice companies better highlight the packaging requirements for a sector compared to companies with limited packaging expertise.

Site Visit Objectives:

1. Observe the product's journey from manufacture to end-users.
2. Gain an overview of the processes involved in developing and producing specific product packaging.
3. Understand the linkages and information flows between packaging suppliers, product manufacturers, distributors, retailers, and end-users.

The following appendices provide an overview of the production line processes for each case study product, the packaging design and selection process, and the current packaging selection.

Matrix Comparison:

Appendix 5 presents a matrix comparing factors influencing packaging choices for each case study product.

Appendix 1: Case Study 1 - High Value Electronic Goods

Computers

Introduction

This case study focuses on the packaging of computers and, specifically, computer monitors. The packaging specified by the company consists of corrugated cartons with internal cushioning provided by various materials, including polypropylene, polystyrene, heat-formed plastic, board, and reconstituted waste pulp.

Sector Overview

In recent years, the dominant trend in the personal computer (PC) market has been lower costs coupled with improved performance. As competition has grown, technology has advanced and therefore prices have become more competitive, the PC market has evolved, with sales volume in the commercial and industrial sectors decreasing annually in favour of sales to the consumer market.

The trend towards miniaturisation is evident, reflected in the increasing market share of portable devices, laptops and the downsizing of conventional desktop PCs. Laptops are the fastest-growing sector of the UK PC market. With the rise of the consumer market, there has been an increase in the direct and customer purchase market, typified by the growth of large retail outlets specifically for electronic goods retailing.

Sector-Specific Packaging Demands

Computers and their components are high-value consumer products which, due to their complex design and extensive use of micro-circuitry, are relatively fragile. The primary purpose of their packaging is to provide sufficient protection for the product to reach the final customer in fully working condition.

The packaging must safeguard the product from impacts, crushing, and vibration during manufacture, distribution, and storage. Additionally, it must prevent the ingress of dirt, dust, and moisture and protect the product from temperature extremes, particularly during transit and storage. Certain electronic assemblies also require extra protection from electrostatic discharge, which may cause product failure.

Theft of individual components from within packaged goods is not uncommon, and the packaging must provide at least a minimum degree of protection from such interference. The relatively bulky size of computer systems mitigates against casual theft of complete systems from retail outlets, although their high value has encouraged some organised theft from the distribution and storage stages.

The Production Process

A computer monitor usually consists of a moulded

plastic case enclosing a tube, a screen, and assorted electronic components. Components are either manufactured on-site or sourced from various locations. A minimum stock of the necessary components is kept at the factory, with the company moving towards a 'just-in-time' stock, order, and distribution system. Thus, components are ordered just before they are needed, units are assembled strictly to order, and then shipped when ready.

The production lines are simple and flexible, capable of building several different products depending on demand. Internal components are first assembled as the machines pass along manual and automatic conveyor lines. The assembled components are then placed inside the plastic cases with the screen facing down. The remaining connections are made, and the case is closed. Component testing takes place at various points on the production line, and the finished monitor is tested again just before it is placed in its packaging for transportation.

Monitors are transported along the production line 'screen down' on their 'front' polystyrene end cap. The other end cap is added before the monitor is manually placed in the outer carton base down to reduce potential vibration damage during distribution.

The Distribution of the Product

From the end of the production line, the packaged monitor is moved by conveyor to an area where robots stack the cartons onto pallets. Corner posts are manually fitted to provide edge protection and extra strength for stacking in the lorry. Another robot stretch-wraps the pallet to retain the load in position and prevent dirt ingress. A 'band wrap' provides extra stability for some pallet loads. Each standardised pallet (1200 x 1000mm) contains 8 monitors with a target pallet height of 1000mm, allowing pallets to be stacked two high inside the distribution lorries.

Monitors are typically transported by lorry to a central distribution 'hub,' from where they are sent to various commercial and private customers in the UK and abroad. Orders may be dispatched to another company location, a dealer, or directly to the end customer. The last form of direct selling was relatively new to the company and involved changes in distribution operations. In particular, couriers may

collect and deliver individual products instead of using bulk transportation methods. In certain circumstances, orders may also be dispatched directly to the customer from the factory, bypassing the hub-distribution centre.

The Packaging Design Process

The responsibility for designing the packaging for computers and computer monitors within the company largely rests with the packaging department. This department comprises packaging engineers and designers who interpret and respond to briefs provided by the product development and marketing teams.

In the past, packaging was treated as a separate function only required once the product development was completed. More recently, however, the role of product packaging has come to the fore, and the packaging engineer plays an essential role at all stages of product development. The packaging department is involved with product development from an early stage and can influence not only the design of the packaging but also, to a lesser extent, the design of the product's casing.

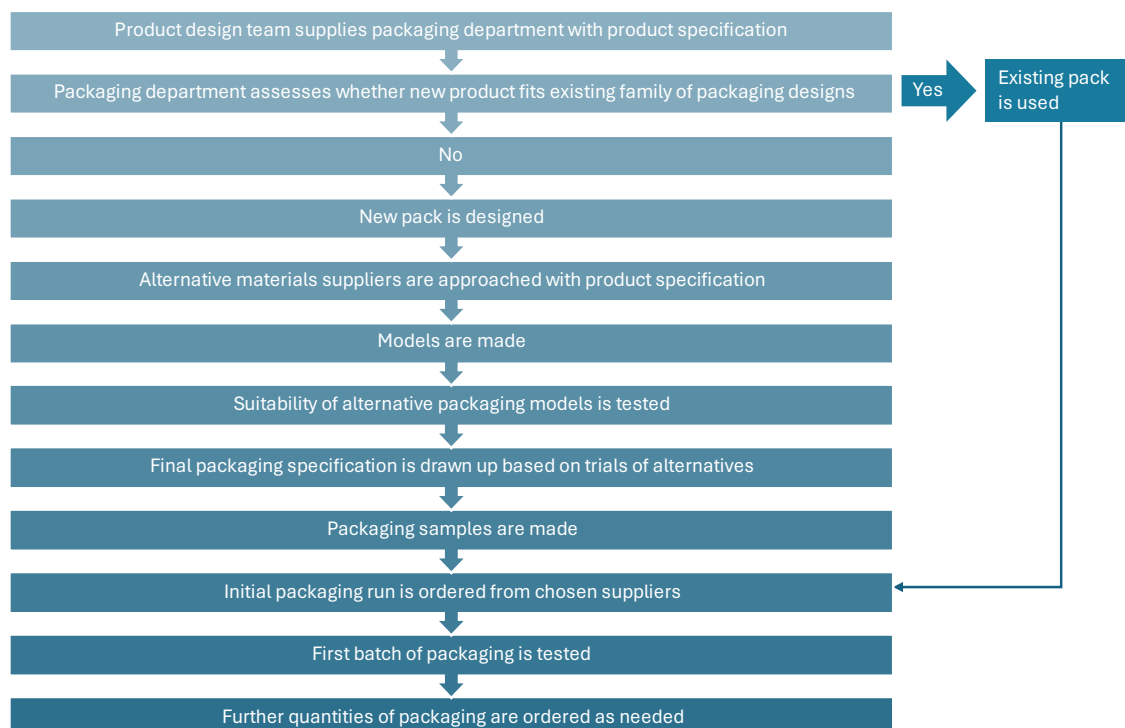
The companies responsible for supplying packaging materials to the computer industry play a vital role in developing new and existing packaging technology. This role has evolved following radical changes in the relationship between computer producers and packaging material suppliers. Traditionally, suppliers were presented with an exact packaging specification by the manufacturer and asked to tender for the job. However, a partnership approach has now been adopted, facilitating closer relationships between companies and encouraging cooperation at all stages of the product design and production process.

In developing a new or updated computer product and its packaging, a meeting is first held to discuss the exact specifications of the product with the relevant departments and to establish a development timetable. As the design of the packaging can be fairly standardised, packaging development work focuses on designing the specific product cushioning within the packaging.

Following a defined development process, prototypes of the product are assembled and tested comprehensively. Provided these tests are successful, the packaging department is given a detailed product brief from which to design its packaging. From this brief, it is determined whether the existing 'family' of packaging components can be adapted or whether a new pack must be designed.

Where a new pack design is required, it is developed in-house, put out to tender (where the specification is already established), or developed in conjunction with the supplier. If the last course is chosen, the packaging department outlines several alternative design specifications to discuss and trial with the suppliers before finalising the choice through a series of tests.

Prototypes are then tested with the product to assess their suitability. A pre-production batch of product and packaging is tested at length before an order is placed for the supply of the packaging.



Product and Packaging Testing

When a new product is developed, both the production line on which it is to be assembled and examples of the finished product itself undergo a series of pre and post production testing programs. New products go through a lengthy testing procedure before the product's packaging is introduced into the testing process.

Following an assessment of the production lines, individual packs, and palletised loads of new products undergo tests to determine the durability of both the product and its packaging. Once a product is in production, these tests are also carried out on products and their packs at random. The tests simulate the strains and stresses a packaged product might experience after leaving the factory.

The packaged product is subjected to drop tests, involving falls from 30 inches onto the 6 faces, 1 edge, and 1 corner of the carton. Packs undergo vibration tests on special rigs, both individually and as part of a palletised load, while the latter are tested for their performance during stacking. The products are also subjected to climatic testing to assess what happens to both the product and the packaging under variable conditions of humidity and temperature.

If a product is found to be damaged on arrival at the end user, the causes of the damage are assessed, and where the packaging is found responsible, it is modified.

Recent Developments in the Product and the Packaging

In recent years, there has been a gradual replacement of polypropylene by polystyrene for internal cushioning. Polystyrene is much cheaper (around half the cost) and provided sufficient protection. The amount of polystyrene used in internal cushioning has also been significantly reduced over the years and is continuously reviewed. By moving from 'clam shells' to end caps and then to end caps

without facings, material usage has been reduced.

Alternatives to polystyrene are also being assessed. For example, paper pulp technology has improved considerably, making it possible to use recycled pulp material for certain products instead of polystyrene. Other materials, such as cardboard, have also undergone significant development. The use of polypropylene or polystyrene for additional cushioning has been significantly reduced.

Current Packaging Specification

The requirements of the packaging are usually achieved through a combination of a strong outer packaging containing various internal product and some cushioning materials.

The outer packaging was typically made from corrugated board of differing specifications. Corrugated board consists of three layers of paper - two external faces (or linerboard) with a layer of fluted board in between to provide extra damage resistance. The external faces of the carton may consist of kraft paper or a mixture of kraft paper and recycled fibres (known as 'test liner'). The fluted board utilises similar materials but is stiffened to provide increased rigidity. Today much of the packaging is made from folding box board to give an even higher end finish as being sold directly to consumers.

The monitors observed in this case study were packaged in corrugated cartons with polystyrene end caps (polystyrene formed to fit around the front and rear of the monitor) providing internal cushioning. Internal cushioning may be provided by various materials.

Depending on the unit's specification, some of the empty space in the packaging was used for accessories, components, and manuals, although these will provide no additional protection. Today the design of the packaging is even more integral to the product and there is much less space in the packaging, to maximise efficiency for supply chain and distribution.

Appendix 2: Case Study 2 - Non-food Household Goods

Liquid Laundry Products

Introduction

This case study focuses on the packaging of laundry products. It is based primarily on an investigation of the packaging of liquid laundry products, with references to powder products as well.

The packaging specifications for laundry liquids included multi-layer blow-moulded plastic bottles, gable top cartons (similar to liquid beverage cartons) consisting of virgin or recycled board and polyethylene laminate, and doy packs - a refill pouch made from a laminate of polyester and polyethylene with a gusseted base to allow the pack stand up.

Sector Overview

There was a steady increase in the demand for laundry detergents in the past. The demand for liquid laundry products, in particular, has seen a marked increase, although this trend has now levelled off. The market is highly competitive, with various brands supplied by a relatively small number of manufacturers.

Sector Specific Packaging Demands

Laundry products are low-value, high-volume items with no inherent protective qualities. The packaging must securely hold the contents from the end of the packaging line until the last of the contents has been used. Primary packaging is protected by secondary packaging to prevent product damage and spillage.

The ingredients in laundry products include various chemicals, some of which can be potentially hazardous under certain circumstances. Therefore, it is crucial to protect other products from the contents and odour by the use of the packaging. Additionally, the product may react with certain types of packaging material.

Packaging for liquid laundry products must resist punctures and be sufficiently flexible to withstand physical pressure without failing and causing spillage.

The Production Process

Filling lines for laundry products can be either flexible - suitable for filling multiple products with varying packaging designs - or dedicated for volume production. Filling may occur on-site or at the filling lines of contract packers ('co-packers'). Packaging may be supplied by external contractors and assembled on-site or manufactured entirely on-site. The laundry product is loaded in bulk at one end of the filling line and transported through pipes in regulated volumes to the filling area, where the container is automatically oriented to receive the product. Once filled, the container passes down the conveyor, receiving a cap and labels (for plastic bottles) before being deposited, into its secondary packaging (e.g., corrugated case). The production process is outlined in Figure II.

The Distribution of the Product

Packed products are taken from the filling lines by forklifts to a transit area, from where they are dispatched by lorry. Products are first transported to a central distribution centre with racked storage facilities. Loads are then consolidated and distributed in bulk by lorry to final customer distribution centres. Products for overseas markets are sent directly abroad without passing through the central distribution centre.

The Packaging Design Process

For laundry products, the marketing and product development teams initiate new product development and usually the re-packaging of existing products. As the relationship between product packaging and marketing has become increasingly important, the packaging department's role has grown more influential. The packaging department now has significant influence at all stages of product development, particularly regarding final pack specification, filling, and distribution requirements.

The process of developing a new or updated laundry product and its packaging starts with the marketing, product development, and packaging teams to write the brief. This includes details of product performance requirements, pack format and size, cost constraints, environmental constraints, and timetable. The required secondary packaging format is also considered as part of the original brief for the primary pack.

If an existing pack is chosen, the marketing department is responsible for differentiating the product from other products that already use that structural pack design. Frequently, an entirely new packaging design or format is required, providing an opportunity to review trends in design and technology to optimise the final packaging choice.

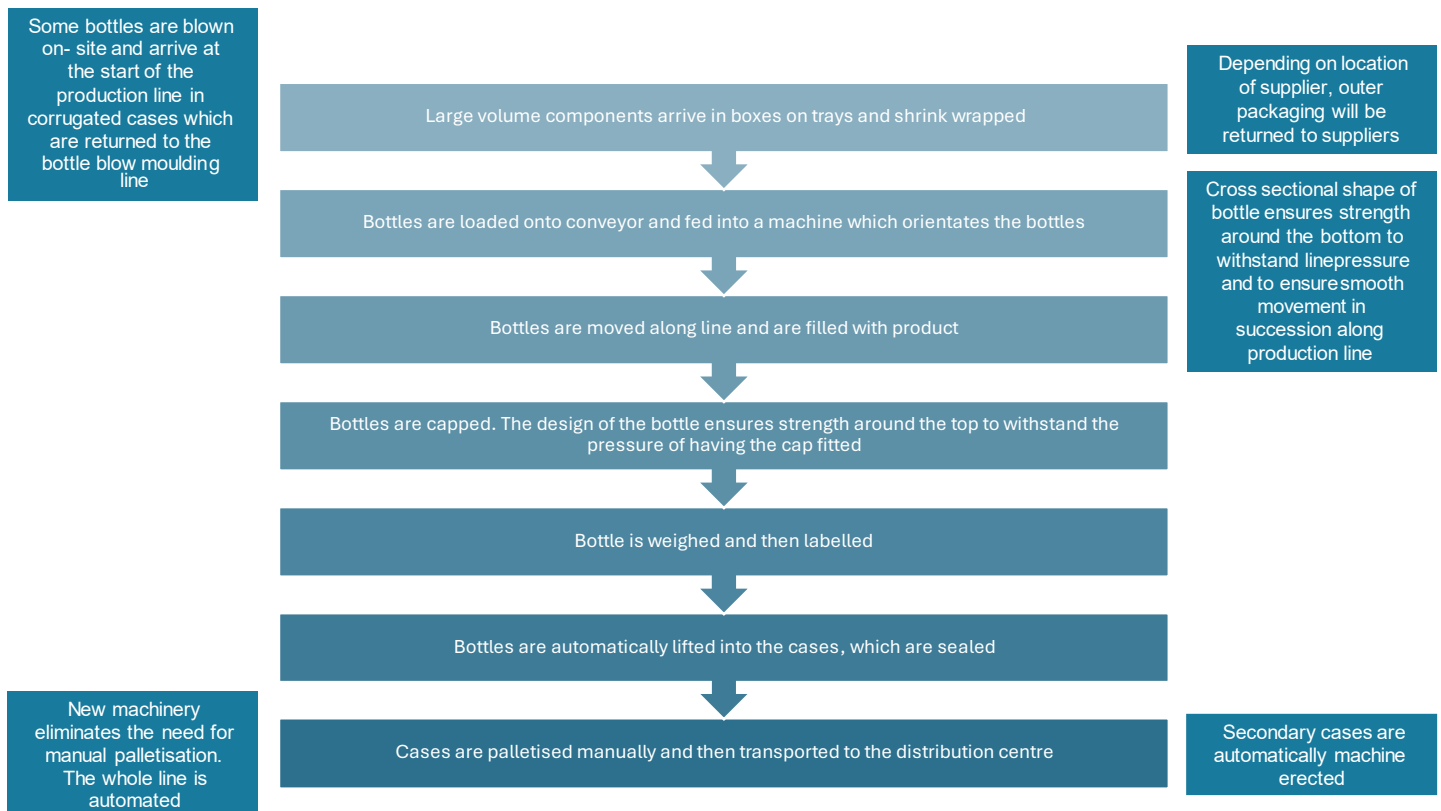
If a new pack is to be designed, a number of design agencies may be briefed, and based on their quotations, one or two will be asked to proceed to the initial design stage, in sketch form or simple foam models. The designs are then assessed technically, with the most promising selected for market research. From the research, one design is chosen and is modelled, prototyped, or possibly a pilot-tool produced. A detailed assessment is made of the design's efficiency and effectiveness during manufacture, filling, sorting, transport, display, use, and disposal. The impact of pack design and material selection is reviewed in depth at each of these stages, and any necessary changes or improvements are made.

Contract packers are often used to establish whether there is a market for an alternative packaging format or design. By using a contract packer, the expense of establishing a new production line is avoided, although the quality of the packaging may not always match that of in-house manufactured packaging.

of the packaging and formulation are available, in-house testing is conducted. Laboratory testing checks pack/product compatibility, stability, performance, and any claim substantiation. On satisfactory completion of these stages, a launch decision is agreed.

Once the design stage is complete and pilot quantities

Figure ii: The Production Process for Liquid Laundry Product



Product and Packaging Testing

In-house tests are initially carried out separately on the primary and secondary packaging and then on the combined packaging. The tests are performed in laboratories and in actual-use conditions. Criteria tested include temperature and humidity resistance, top load strength, compression resistance, drop strength, tensile strength, resistance to stressing and cracking, product compatibility, product stability, leak testing, cap tightness and security, label adhesion, etc. Much of the packaging on the company's laundry products is designed to withstand pallet stacking to a height of three pallets for 3-6 months and is tested to beyond these specifications.

In addition to in-house testing, packaging suppliers undertake their own testing. For example, corrugated case manufacturers test their own packs for resistance to various stresses, including vibration, compression, and humidity.

Once a packaging design has been selected, a line trial tests the packaging's performance through the production line. Ideally, this takes place before the start of production. Time pressures may preclude comprehensive testing at this stage, and the packaging department may rely on in-use data from earlier testing. Subsequently, tests are conducted to optimise material usage by lightweighting wherever possible.

At later stages, packaging may be modified based on experiences at different stages of the product's life.

Weaknesses in the design that were not identified during initial prototype testing may become apparent during production. Collecting data on packaging performance through testing, experimentation, and monitoring is crucial and is generated by the packaging team during various test stages. Feedback from distribution centers occurs if specific in-use problems are encountered throughout the product's life. If appropriate, specification and design may be changed.

Increasingly, packaging undergoes distribution tests. The basic test monitors a palletised load from the production line to the company's UK distribution center or its European distribution center. On arrival at its destination, the pallet is stripped down to assess the packaging's performance during transport.

If there is product loss during the distribution testing stage, experiments are conducted to identify the packaging's weakness. A development in the company's testing program is the incorporation of a 'black box' computer monitor into selected pallet loads. This device identifies and records the stresses, such as vibration and humidity, to which a packaged product is subjected during actual in-use distribution operations. The collected data provides greater insight into the packaging's performance than laboratory tests alone and can identify specific inadequacies in the packaging specification. Cumulative data of this nature improves the packaging team's ability to specify the optimal pack specification from an early stage in its development.

Table I: Current Primary Packaging Specifications for Laundry Products

Powder

Standard solid carton board	This was the traditional pack for laundry powder. It is usually made of white-lined chipboard and is available in a range of standardised generic sizes. The recycled content can be up to 80% but the outer layer is usually made of virgin paper.
Composite paper bag	This consists of a paper/polythene laminate. The very thin polythene liner enables the bag to be heat sealed and therefore offers moisture and odour barrier properties. The bag uses substantially less material than a conventional solid carton board although it cannot easily be separated into its constituent parts for recycling and requires a strong corrugated case to offer top load strength in transit and storage. It is designed to be used as a refill pack, although it can be used as a stand-alone pack with a scoop.
Plastic container	This is of a similar construction to those used for liquids with a different design of pouring/scooping system (see diagram below).
Tin box	This is a refillable rectangular tinplate container with a hinged or loose lid which usually contains a refill bag and scoop. Replaced today with a recyclable plastic or carton board alternative.

Liquid

Plastic bottle

The trend in plastic bottle use for laundry products was multi-layer blow moulding in place of the original single layer technology used for many other packs. Multi-layer technology enables the incorporation of around 25% of recycled plastic, normally sandwiched between two layers of virgin material. The thin skin of virgin material on the outer layer preserves the visual appearance of the pack. Today the recycled content can be up to 100% with some closed loop initiatives by brands and the packs are recyclable.

Polythene bottles tend to have high impact strength but top load strength is relatively weak.

Gable top carton

This is similar to liquid beverage cartons in design and consists of a virgin or recycled board and polythene laminate. Initially designed as a refill, but is used as a stand alone container as it has an in-built spout. The board may contain a proportion of recycled material but the use of high proportion of recycled board may result in the separation of the board from its liner.

Recent Developments in the Product and the Packaging

The growth for laundry products has been accompanied by an increase in the range of product and packaging formats available to consumers. There has been a shift away from laundry powder in standard-sized cartons to various pack types. This has been made possible by factors such as the development of concentrated powder and liquids requiring smaller packs and the introduction of refill packs.

Current Packaging Specification

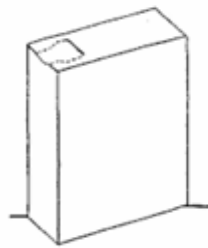
Primary Packaging

Some of the primary pack designs used are illustrated in Table 1.

Secondary Packaging

A standard corrugated case is usually specified for secondary packaging. The middle corrugated layer is made up of recycled material, while the inner and outer liners may be made of virgin fiber, recycled fiber, or a mixture of both.

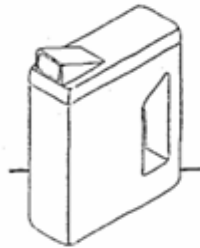
Figure Iii - Diagrams of Packaging Options for Laundry Products



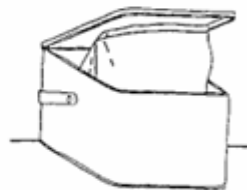
Standard solid board carton



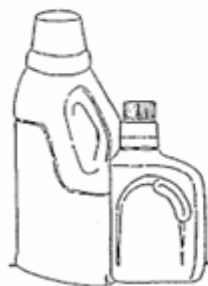
Composite paper bag



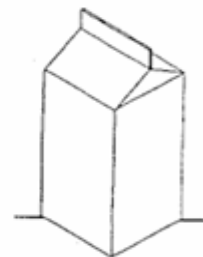
Plastic container



Tin box



Plastic bottle



Gable top carton



Doy pack

Appendix 3: Case Study 3- Food Goods

Frozen, Chilled and Fresh Fish Products

Introduction

This case study focuses on the packaging of frozen whole fish and fillets, as well as frozen and chilled fish ready-meals.

The primary packaging specifications for the case study products include coated cartons and polybags for portions and block-based fish products, coated cartons for breaded fillets, overwrapped crystalline polyester (CPET) trays with a sleeve for premium chilled ready-meals, and unlidded/lidded ovenable board trays with a sleeve/carton for frozen ready-meals.

Sector Overview

Today, the market for fish continues to be dominated by frozen fish fillets and prepared fish. However, the chilled and frozen prepared meal sector has seen substantial growth as convenience remains a priority for consumers.

In the UK, the frozen fish market is expected to grow from £20.80 billion in 2024 to £22.43 billion in 2025, with a compound annual growth rate (CAGR) of 8.8%. The market for frozen fish and seafood in the UK is projected to reach 598K tons and £3.31 billion by 2035.

As for prepared meals, the UK ready meals market has also experienced growth. Retail value sales of ready meals and ready-to-cook foods were estimated to grow by more than 7% in 2024. Chilled ready meals remain the most popular, with nearly three-quarters of UK adults consuming them in the three months leading to May 2024.

The average family's weekly food bill, total expenditure on food and drink in the UK was £43.33 per person per week in the financial year ending 2023. This includes both household food and drink and food eaten out. While the exact percentage of prepared meals in an average family's weekly food bill is not specified, the increasing popularity of ready meals suggests a significant portion of the expenditure is dedicated to these convenient options.

Sector Specific Packaging Demands

For fresh, chilled, and frozen fish products, as with any food products, the packaging must protect the product against physical, chemical, or biological deterioration to ensure that it reaches the consumer

in an undamaged condition. Failure to do so may not only deter purchase but also have health implications for the consumer.

Health and hygiene issues are of particular concern for producers of fish and shellfish products. The products need to comply with strict legislation concerning temperature, moisture, oxygen, odours, and discoloration. The packaging must facilitate compliance with such legislation by ensuring food quality and providing sufficient information for consumers.

Packaging for fresh, chilled, and frozen fish products must contain the product effectively. The product should not leak or lose small solid pieces. Liquid containment is a priority for chilled fish packaging, while frozen food packs need to contain small pieces of the product, such as crumbs, breading, and other added ingredients.

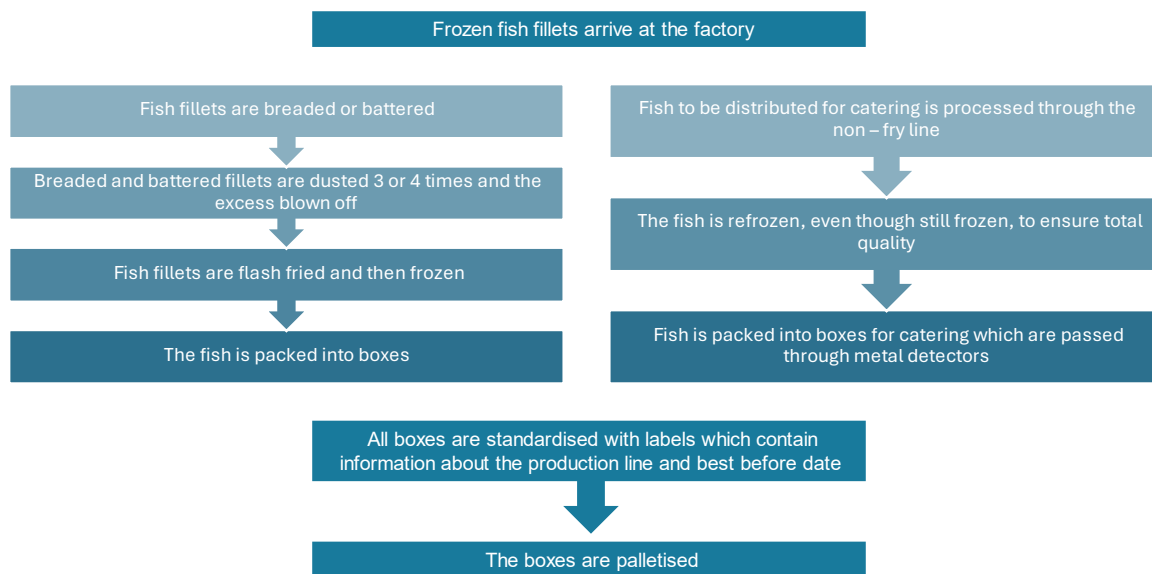
Packaging must also assist in the preparation and use of the food by the consumer, and therefore may need to withstand extremes of temperature and humidity. Food may be cooked directly from frozen, so the packaging might need to withstand both oven and microwave cooking.

Manufacturers have been required to take increasing precautions against deliberate tampering. Primary packaging is typically lidded and sealed before passing through a blast freezer, and then primary packaged. These primary packs are then packed in secondary cartons for cold storage and dispatch.

The processing method for chilled ready meals depends on the specific product. Today most of the ready meal being prepared off-line and then added to the tray for immediate cooling, and then lidding or overwrapping.

Chilled ready-meals are primarily packaged through 'Tiromat' lines, where the individual meal is placed into standardised CPET trays and lidding film. The processing lines are extremely flexible, enabling rapid changeovers between different ingredients and meals. This flexibility is particularly necessary for chilled ready meals, which have very short lead times and may involve only short runs of each product, depending on demand.

The Production Process for Frozen Fish



The Distribution of the Product

The boxed, frozen fish and prepared fish products are loaded onto pallets at the end of the production line and shrink-wrapped. The pallets are then loaded directly onto refrigerated lorries or taken by forklift to the adjoining refrigerated storage and distribution center.

Chilled ready meals are placed onto stacked plastic trays with no additional secondary packaging. The products are delivered to retailers on these trays, which are then returned by the retailer to be washed for re-use.

The Packaging Design Process

The marketing and product development teams initiate the development of a new product. The packaging team is involved at an early stage in the product's development and assesses whether the company's existing packaging is suitable for use.

If a new pack is required, it is chosen based on criteria such as the product's price point, specific characteristics of the product sector, size of the product (considering variable sizes, especially seasonal differences), timing of launch, regulatory and environmental constraints. The size specifications for the packaging are drawn up with reference to standardised pallet stacking and retail shelf space.

If a new packaging design is created, a sample of the packaging is produced and size-trialled on the production line. The specifications are then sent to the company's packaging suppliers, who manufacture a proof of the pack. If suitable, an initial production run is produced; otherwise, the design is amended and re-checked. Packaging may be modified later based on experiences at the production, storage, and distribution stages.

The relationship with packaging suppliers is one of 'partnership in problem-solving.' New packaging technology often comes from suppliers, either through buying in technical expertise or from suppliers innovating to maintain and gain business.

Product and Packaging Testing

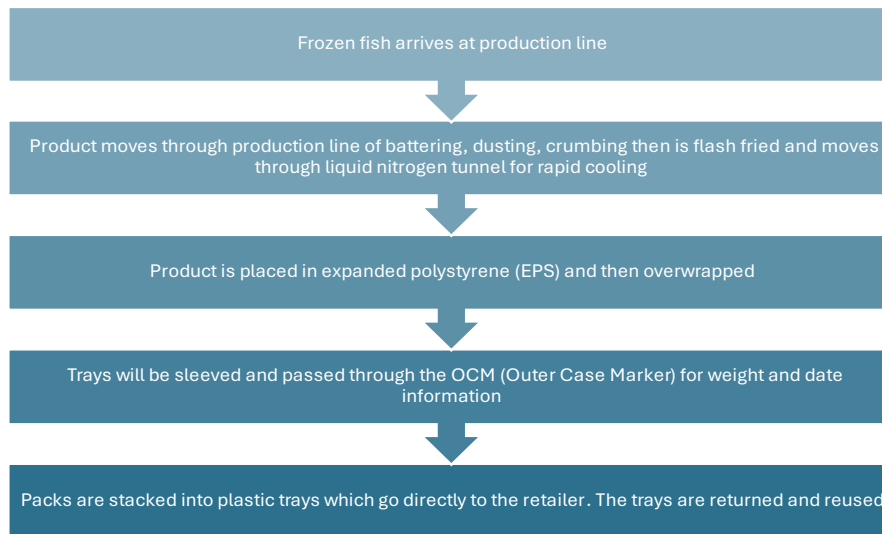
Most of the packaging used by the case study company is of proven design and has been extensively tested. New packaging is tested jointly in-house by the case study company and packaging suppliers, often using product trial runs through the packaging line and distribution system.

Recent Developments in Product and Packaging

The market for microwaveable ready meals led to significant changes in production methods and packaging specifications. The introduction of coated boards suitable for conventional and microwave ovens ('dual-ovenable') has had a major impact on frozen ready meals. These boards are unaffected by blast freezing, can be cold-stored for long periods, offer minimal resistance to microwave radiation, and can be heated in conventional ovens while retaining rigidity.

The availability of a wide range of plastics with different properties has enabled the development of modified atmosphere packaging (MAP) and controlled atmosphere packaging (CAP) to prolong the shelf life of fresh and chilled foods. Perishable foods last longer if kept cool and if sealed plastic packs are flushed with appropriate mixtures of oxygen, carbon dioxide, and nitrogen. Plastics used for the tray and lid/overwrap must be impermeable to both air and the introduced gases, capable of being fused to produce an effective seal, and treated to prevent misting.

The Production Line for Chilled Fish and Prepared Meals



Current Packaging Specification

Primary Packaging

The packaging chosen for fresh, chilled, and frozen fish products depends on specific product requirements. Table 2 outlines the possible primary packs.

Secondary Packaging

The case study company uses a family of standardised brown cartons for secondary packaging, containing recycled material. These are sized to fit the pallets used by the company. All outer casing arrives in flat pack form and is assembled on the production lines. Due to the variability in the size and weight of fish products, variable information labels are required on every outer case.

The secondary carton may contain a polythene liner to help absorb moisture and grease. The filled outer cartons are placed on pallets and shrink-wrapped.

Packaging of Frozen Food for the Catering Industry

The case study company is also a wholesale distributor of frozen food to the catering industry.

Primary Packaging

The demands placed on primary packaging by the wholesale industry are very different from those of the retail sector. The caterer is supplied with products in bulk, which allows many products to be supplied without individual primary packaging. The caterer makes the selection from the price catalogue, and the consumer makes their selection from the caterer's menu - therefore, there is no requirement for the packaging to encourage consumption or purchase through its design or graphics.

The case study company does not provide a detailed specification to external product suppliers for the primary packaging, and various methods may be used.

Secondary Packaging

Secondary packaging needs to protect the product during transport - its aesthetic appeal is of negligible importance. The size of the carton is not important for distribution purposes, and most loads are of mixed carton sizes. The loads are consolidated, and the vehicles are not necessarily stocked to capacity.

The case study company recently changed its secondary packaging specification. All products had been distributed to the caterer in bleached, white kraft cartons, but there was a shift to unbleached, recycled cartons. The cartons are differentiated by seven different colours of print, corresponding to different sectors in the price list. One consequence of the shift to recycled cartons has been the need to introduce barrier materials inside the carton to separate the product from recycled fibres, which may cause contamination.

If a new product is developed, either by the case study company or one of its suppliers, generic packaging may be used. If the case study company considered that the product will be successful, they will specify their standard secondary packaging from the outset.

The Packaging Suppliers

The suppliers of the case study company's own-brand catering products are issued very detailed packaging specification guidelines. The guidelines

include specifications for paper materials, corrugated board composition, case liners, inks, and the printed design. Developments in packaging technology are communicated to the suppliers through the guidelines, which are updated as necessary.

The suppliers are required to notify the company's packaging department of any changes to the packaging specification. If the supplier is temporarily unable to abide by the specifications, the case study company may request that its name is not added to the box. This ensures consistency of brand and company image on the secondary packaging

Table: Primary Packaging Specification for Fresh, Chilled and Frozen Fish Products

<u>Fresh whole fish</u>	Food retailer supplied - pre-packed in expanded polystyrene (EPS) with overwrap and label, possibly with modified atmosphere for increased shelf life
<u>Chilled</u>	Whole fish/portions - clear overwrapped EPS tray with modified atmosphere and label or sleeve depending on price point Ready meals - overwrapped crystalline polyester (CPET) tray enclosed in sleeve with full colour photograph and information. Modified Atmosphere Packaging (MAP) may be used to extend shelf life. Modified atmosphere may use a CO ₂ /N ₂ gas mixture Shellfish - EPS tray with a clear overwrap
<u>Smoked Fish</u>	Vacuum packed in a pouch with either a simple label or within a coated carton
<u>Frozen</u>	Whole uncoated fillets, prawns - transparent polybag with information Coated fillets - transparent polybag/carton with photograph and information or white opaque fully printed polybags Scampi - white opaque polybags with heavy colour printing or photographic reproduction of product Ready meals - dual ovenable board or CPET or aluminium foil tray with lid enclosed in carton with full colour photograph and information. The case study company recently changed from packaging the frozen ready meals from plastics to dual-ovenable board trays Fish in sauce - a vacuum sealed pouch which can be boiled in the bag or microwaved. Sold either individually or in cartons of four

Appendix 4: Case Study 4 - Cosmetic Goods 4a - Skin Care Products

Introduction

This case study focuses on the packaging of skin care products, specifically cream moisturising lotion. The case study company is a contract manufacturing company that manufactures and packages products developed by its customers. It also develops product packaging for several customers. The packaging specification for the case study product is a PET bottle, which is clear, squeezable, and tapered.

Sector Specific Packaging Demands

The bottle for the moisturising lotion is required to be robust enough to withstand production, distribution, and retail operations. The artwork on the bottle is designed to endure most handling eventualities without degradation.

The packaging is also required to portray the product's quality and effectiveness. As the packaging is an integral part of the product, its design must be appealing to the consumer if it is to be displayed at the point of use, e.g., bathroom. Purchase choice may, therefore, be strongly influenced by subjective judgments based on the aesthetics of the packaging.

The choice of material for the bottle is based on its compatibility with the product's formula and the potential for product weight loss. The product should not deteriorate in the presence of direct sunlight, and it is sometimes necessary to add ultraviolet (UV) inhibitors to the PET formula. However, this may make the bottle more brittle and susceptible to breakage.

There is no requirement for tamper-resistant/evident enclosures in this case study product.

The Production Process

A product formula is developed by the customer, and the appropriate ingredients are held in stock or ordered by the manufacturer (the case study company). The ingredients are prepared according to the customer's recipe and are piped to the product line.

The bottle passes down a custom-tooled line, is labelled (where applicable), and filled before having the cap fitted to a pre-determined torque. The filled bottles are either placed in a corrugated box (in twelves) or placed in a tray and shrink-wrapped. An identification label is then added.

For high-volume products, the line is dedicated and consequently difficult to adapt for other products. Conversely, the lines for lower-volume products are designed to be fairly flexible, allowing more efficient changeover between different products.

The corrugated boxes or shrink-wrapped trays are palletised according to a pre-set layout to ensure maximum space utilisation. The pallets are stacked to a pre-determined height and taken to the on-site warehouse. From here, the pallets are taken by independent distributors to the customers' warehouses, from where they are distributed to retail outlets.

There is limited monitoring in the distribution chain. The contract manufacturer's role is considered complete when the product leaves the production line.

The Packaging Design Process

The design of the packaging is very much 'brief-driven.' The customers carry out the market research and determine the packaging specifications, which the case study company is required to follow.

If the customer's brief contradicts the case study company's environmental policy, discussions will take place to modify the specification. The case study company checks the wording on the packaging, chosen by the customer, for conformity with legal requirements and to prevent any unsubstantiated claims from appearing.

The secondary packaging is designed largely to meet handling requirements. It provides limited protection, although print protection is considered important.

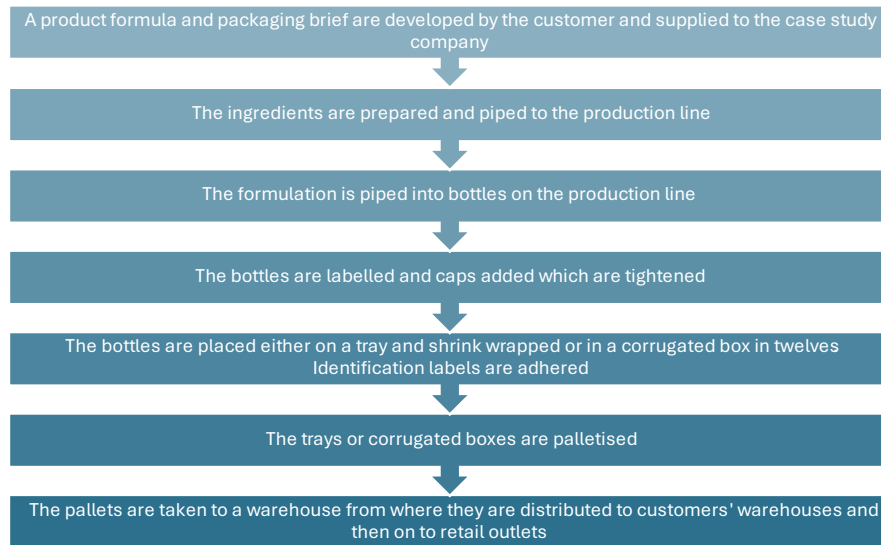
The case study company operates a core group policy, which minimises the number of packaging suppliers used. It works in partnership with larger suppliers and uses competitive tendering processes for packaging materials purchase.

Product and Packaging Testing

Most of the packaging testing is carried out by the packaging suppliers. However, the case study company conducts manual testing for leakage, vibration, and drop tests for packaging integrity.

In response to customer orders, the case study company undertakes a production run that allows for some product loss in manufacturing and distribution (i.e., extra products are manufactured beyond the ordered quantity). The number of extra units produced is based on experience from previous production.

The Production Process for Moisturising Lotion



Recent Developments in the Product and the Packaging

The skin care product market is generally considered conservative, and the design of the packaging has changed little in recent years. There was limited demand for packaging innovation from the case study company's customers. Today there is much more innovation in this area and customers expect packaging to be recyclable, refillable or reusable.

Current Packaging Specification

The tapered bottle used for the moisturising cream is

not optimal for production line and handling operations - a cylindrical bottle would be more efficient. The tapered design tends to slow down the production line and can lead to blockages (they are more susceptible to falling over on the line). They are also less efficient for secondary packaging volumes.

The bottle is thick-walled, affording a far greater degree of product protection than actually required. Its weight is dictated by marketing considerations, which require the bottle to approximate the feel and weight of a glass bottle.

Case Study 4b - Fragrances

Introduction

This case study focuses on the packaging of perfume and eau de toilette products. The packaging specification for the case study products is a glass bottle or atomiser in a chipboard liner.

Sector Specific Packaging Demands

The industry is primarily design and marketing-led, and the product and its packaging are virtually inseparable in terms of product and packaging chain demands.

The design of the packaging for a fragrance is concerned as much with image as it is with functionality. The visual image of the product is extremely important to the consumer, and initial purchase may be influenced more by packaging design than the product itself. The second purchase will depend more on the quality of the product.

The packaging must be compatible with the product and must protect it from shock and vibration during distribution. If a perfume bottle breaks and the contents spill, it may damage all the cartons in the secondary packaging. It is particularly important to contain the scent until it is applied by the user.

The packaging for the case study products did not require extra tamper-proofing, as at the time most products were sold behind the counter and testers are available. However, in today's retail outlet products are displayed on the shelf for customers to select, this has led to the introduction of tamper evident labels and security tags.

The Production Process

The diverse nature of fragrance packaging demands production flexibility. The case study products pass down the line on custom-made 'pucks' that hold the individual bottles. This allows various packaging shapes and sizes to be accommodated on the same line.

The bottles move along the production line and are packed automatically into individual cartons. Each individual carton may be overwrapped before being placed into standardised secondary packaging (corrugated), which is then palletised. If there is any 'headspace' (unused space around the product) in the secondary packaging, it is filled with reusable packaging.

The Distribution of the Product

Once the product is filled and packed, it is transported to the company's distribution hub, where it is quality inspected. It is then distributed from the hub to the retail outlets. The case study product arrives at the retailers in individual chipboard liners, which are removed before display at the perfumery. (The case study company previously used reusable plastic trays for distribution, but this led to increased pilferage of the product).

The case study company had focused on improving warehouse efficiency. The aim was to minimise both handling and case changes. 'Pack out' (distribution) efficiency has also been improved by using distribution carton sizes that more accurately match the quantities ordered by the retailer, e.g., 24, 48.

The Design Process of the Packaging

The marketing department, in conjunction with external designers, initially produces a design concept or product image for consideration by the company's in-house designers. The packaging designers are involved from the early stages of product development.

The core design and image of the fragrance are identified and developed in concert with the packaging specification. The secondary packaging is considered at the same time as the original primary packaging design, but the primary pack design is rarely changed solely to reflect secondary pack specifications. Changes in specification may be incorporated after the initial brief, although deviation from the original design concept is minimised.

Each year, the company conducts an internal audit of overall packaging costs and performance. It is at this point that modifications to the packaging design, such as lightweighting, can be assessed.

While the case study company works with a variety of external designers, it partners with each supply company to achieve the best possible option within the packaging requirements. Occasionally, suppliers approach the case study company with innovative approaches to packaging demands, but most developments occur through continuous internal review of specifications.

New developments in packaging technology and design are generally communicated through trade journals. There is limited benchmarking between companies because of the highly competitive nature of the market.

Product and Packaging Testing

If existing packaging is to be used (e.g., glass bottle with pump), the testing is fairly limited as its specification will be based on prior experience with the packaging.

If a new packaging specification is to be used, however, line testing will be carried out before the start of production. Tests are made on the cartons and liners using models, and further testing is carried out during distribution operations.

Recent Developments in Product and Packaging

The competitive and profitable nature of the market encourages the continued development of new products. Originality is the key aim, with product differentiation largely relying on packaging design and product price.

The market has witnessed increasing 'globalization' of the product and its packaging. Traditionally, packaging for the same product has varied between different countries, but today, largely as a result of production simplification and cost reduction policies, products are specified to a single size and specification worldwide.

A further trend in the market was a shift to simpler designs of packaging. This enabled companies to move from hand assembly to automated production and thereby reduce costs.

Current Packaging Specification

The case study product is available in coloured frosted glass bottles as eau de toilette (1 fl. oz/30 ml) and perfume (0.25 fl. oz/7.5 ml). Both glass bottles are the same shape and have the same designs on the glass. The eau de toilette bottle has a vaporiser and a plastic top. The perfume bottle has a plastic stopper with a metal top.

Both bottles are packaged in individual primary packaging:

- The eau de toilette bottle is packaged in a chipboard liner with the same design and colour as the bottle. It is cushioned with thin corrugated card.
- The perfume bottle is packaged on a plastic stand with a plastic puck to secure it. This is packaged in a cylindrical plastic case of similar design and colour, cushioned with foam. The cylindrical case is then placed in a plain carton, which is removed by the retailer.

Secondary Packaging

The primary packs are distributed via corrugated cases of varying sizes.

Appendix 5: Matrix of Packaging Demands

	High Value Electronic Goods	Non – Food Household Goods	Food Goods	Cosmetics	
The Case Study Product (s)	Computer monitors	Laundry liquid	Chilled and frozen fish products	Skin care products	Fragrances
Relative price	High	Low	Low	Medium	High
Added Value – production costs: sale price	High	Low	Low	Medium	High
Shelf life	Long	Medium	Variable	Medium	Medium
The Purpose of the Packaging					
Protection from Product					
Need for product containment	Low	High	High	High	High
Protection of Product From: (the vulnerability of the product)					
Physical damage	High	High	High	High	High
Biological damage	Low	Medium	High	High	High
Chemical damage	Low	High	High	High	High
Climate damage	Medium	High	High	Medium	High
Malicious actions	Low	Low	High	Medium	Medium
Pilfering	Low	Low	Medium	Medium	High
Production					
Need to facilitate movement through the production line	Medium	High	High	Medium	Low
Flexibility of production line	High	Medium	High	Medium	High
Handling and Distribution					
Use of standardised distribution systems	High	High	High	High	High
Need to contain awkward / small items	High	Low	High	Low	High
Storage Conditions					
Potential for long term storage	Low	Medium	Variable	Variable	Variable
Potential for extreme conditions	Medium	Medium	High	Low	Medium

Retail Requirements					
Role of DPP	Low	High	Medium/High	Medium	Low
Pressure of retail policies	Low	High	High	High	Low
Marketing Requirements					
Need for corporate identification	Medium	Low	Medium	Medium	Medium/High
Need for point of sale product identification	Low	High	High	High	High
Need for product differentiation	Low	High	High	High	High
Need for image projection	Medium	High	Medium	High	High
Legislation					
Legislation on materials selection and use	Low	Medium	High	Medium	Medium
Legislation on provision of information	Low	High	High	High	High
The Demands of the Consumer					
Importance of ergonomics	Low	High	High	High	Medium
Need for openability	Low	High	Medium	Medium	Medium
Need for prevention of inappropriate use	Low	Medium	Medium	Low	Low
Need to convey product information	Low	High	High	Medium	Medium
Meeting consumer expectations	High	Low	Medium	Medium	High
Environmental Considerations					
Importance of disposal volume	Low	High	Low	Low	Low
Importance of packaging recyclability	Low	Medium	Medium	Medium	Low
Use of recycled materials	Medium	Medium	Medium	Medium	Medium

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UK CENTRE FOR ECONOMIC AND ENVIRONMENTAL DEVELOPMENT (UK CEED)

The UK Centre for Economic and Environmental Development was an independent charitable research institute, operating 1984- 2017. They worked to advance the integration of practicable, cost-effective environmental policies as part of the UK's economic development, working with national and local government, enterprise, academic research bodies and professional and non-governmental organisations.

The Industry Council for Packaging and the Environment (INCPEN) works to advance circular economy packaging systems for a net zero world.

We are a membership and research organisation bringing together global packaging manufacturers, brands, retailers and recyclers. We work collaboratively across the whole packaging value chain with others who share a vision of the future where production, distribution and consumption have minimal environmental impact.

An up-to-date list of INCPEN members is on our website www.incpen.org



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