Impact of international, open standards on circularity in Europe

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This report was commissioned by GS1 in Europe, to impartially evaluate the regulatory context pertaining to the implementation of a Digital Product Passport, and the impacts associated with differing implementation scenarios dependent on the standards adopted.

We would like to extend a special thank you to all those who supported this project in the research phase, and all stakeholders who provided expert opinions and feedback.

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Executive Summary

The new Circular Economy package released by the European Commission constitutes a watershed moment, which is expected to serve as a strong catalyst towards a sustainable consumption paradigm. An important crux of this package includes a reform of Ecodesign laws under the Sustainable Products Regulation. The Digital Product Passport is proposed as a key mechanism through which EU economies will support sustainable consumption and production.

Context and Drivers

Accelerating the green transition is one of the key priorities of the European Union for the coming decade. To achieve this goal, in 2019, the European Commission presented an ambitious policy roadmap – the European Green Deal (EGD). Achieving the EGD objectives will not be possible without fundamental shifts in both global and European economic resource and data flows.

The EU Circular Economy Action Plan (introduced by the Commission in 2020) forms a key pillar of the EGD – structuring measures designed to support a transition to a circular economy. The newest and cross-cutting measure of the Plan is the Ecodesign for Sustainable Products Regulation (ESPR).

As announced by the EU, to further enable improved resource flows and supply chain management, the ESPR should also include measures supporting the roll-out of Digital Product Passports (DPP). As the name suggests, these Passports will be assigned to each product covered under the regulation, providing key data on the product's characteristics and origin – data which is required to more effectively identify, track and manage resources across a product's complex value chain, incentivise improvement of sustainability performance, and ultimately support the sustainable purchasing decisions of consumers.

However, while the ESPR provides a key framework defining much of the scope and purpose that DPPs must serve, a number of key variables remain as yet unknown – dependent on the delegated acts which will provide further details and specifications, shaping the practical course of implementation.

One of the new mandatory and essential requirements is that the EU DPPs need to be fully interoperable among themselves in relation to the technical, semantic, as well as the organisational aspects of end-to-end communication and data transfer and this has been an important pillar of our analysis.

Study Outcomes

The net benefits of a Digital Product Passport (DPP) will heavily depend on implementation costs. On a macroeconomic level, a product passport will increase the productivity of the European economy, enabling the achievement of a circular economy through an efficient data-based mechanism.

Increased traceability and availability of data will bring a new level of transparency in the marketplace, enhancing efficiency and enabling new business models. The benefits of a well-designed product passport are extensive, including enhanced product safety and tougher counterfeiting resiliency.

This study discusses the importance and value of global, open standards to today's supply chains, citing both opportunities and challenges related to implementation cost, maintenance of systems, impact on economic operators and, ultimately, costs and benefits to taxpayers and consumers.

The report concludes that there is significant value in using existing global, open data standards for supply chains as the foundation for DPP implementation. The reasons for this conclusion are a combination of cost minimisation, speed to market, familiarity to stakeholders, opportunities for consumer transparency, data integration potential, data interoperability and market creation possibilities.

Solutions based on competing proprietary standards, by contrast, would not only need more time to be developed, but also would create unnecessary additional costs:

- Multiplication costs of development and maintenance of differing standards / systems in parallel
- Costs related to operating and interfacing with competing identification standards
- Costs related to integration of differing data models to comply with a select standard.

As opposed to a scenario under which an open product data standards system can be followed by all economic actors, a scenario under which actors at all stages of a complex value chain must deal with many conflicting identification standards and data models would result in significant additional costs and management burdens. These costs will compound and pass down the value chain – ultimately burdening end consumers and slowing down the circularity goals.

From the three scenarios analysed, the costs would be by far the biggest in the case of competing standards (Scenario 2). Besides significant costs for manufacturers and retailers, transaction costs in the economy would go up, distorting competition. Unleashing the potential of data from a DPP would also require additional outlays. These factors would create costs in the range of EUR 63 billion to EUR 152 billion over the next 10 years.

Scenario 2, is in large part, the costliest, as a result of unnecessary duplications of costs on the side of economic actors forced to adapt to multiple competing data standards which ultimately are still performing the same task. With data integration and aggregation occurring on many levels in each country, the complications and costs of DPPs risk exponential growth. Whether it is retailers or manufacturers who bear the greatest burdens of adaptation will largely be a function of differing bargaining powers – but costs will be duplicated nevertheless.

Furthermore, such unnecessary costs would cause frictions disturbing competition and thus undermine the efficiency of the European economy. The efficiency achieved in Scenario 3, by contrast, hinges on an open, global, decentralised standards based system, which serves to mitigate the risks of such duplications.

In order to evaluate the impact of differing DPP implementation models, we analysed three illustrative scenarios.

Estimated costs associated with implementation of a DPP, including costs related to integration and market distortions over a 10-year period:

1. **Institutional centrally-managed standards / specifications model:**

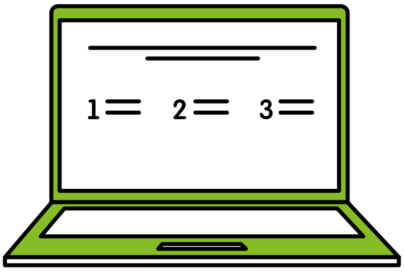
   Between EUR 9 billion and EUR 18 billion

2. **Competing proprietary standards and systems:**

   Between EUR 63 billion and EUR 152 billion

3. **Global, open, decentralised standards based model:**

   Between EUR 3 billion and EUR 7.1 billion



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Context of the report

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Accelerating the green transition is one of the key priorities for the European Union for the coming decade. To achieve this goal, in 2019 the European Commission presented an ambitious policy roadmap – the European Green Deal (EGD).[1]

A transition to a circular economy has been estimated as potentially yielding $4.5 trillion in economic benefits by 2030.[2] Therefore, the EGD is not merely an environmental strategy – it is also an economic strategy, focused on building more resilient economies which use available resources in a sustainable way. This aspect of the EGD has become ever more important since its launch, as the global economy is facing disruptions with regards to resource markets and supply chain risks in the aftermath of COVID-19.

Achieving the EGD objectives will not be possible without fundamental shifts in both global and European economic resource flows. Most of these flows are currently linear: from resource extraction, manufacture, and use of products, to the discarding of waste (which includes valuable resources). According to Eurostat, almost 90% of material resources used in the EU are lost after their first use.[3] Between 2008 and 2018, the EU saw only a modest growth in the proportion of "secondary raw material" consumption – from 9.2% to 11.9%.[4] The circular economy provides both a sustainable alternative to conventional flows, and new business models; through a systemic approach to product design, production, distribution, use and collection, it is possible to circulate products and materials within value chains while minimising resource extraction, waste generation, and carbon emissions.[5]

The importance of transitioning to a circular economy is recognised in the European Green Deal, as well as in the EU Circular Economy Action Plan[6] introduced by the Commission in March 2020. The key cross-cutting measure of the Plan is the Ecodesign for Sustainable Products Regulation (ESPR), which text was just proposed on 30 March 2022, building on the existing Ecodesign framework, which sets ecological requirements for energy-related products. The ESPR will aim to reduce the negative environmental impacts of products and improve the functioning of the internal market, all the while implementing efficient digital solutions.[7]

As announced by the EU, to further enable sustainable resource flows, supply chain management and empower consumers, the ESPR should also include measures supporting the roll-out of Digital Product Passports (DPP). As the name suggests, these Passports will be assigned to each product (similar to individual, national passports), providing key data on a product's characteristics and origin – data which is required to more effectively reuse and/or recycle in the future. The DPP will allow to electronically register, process and share product-related information across supply chain networks, businesses, authorities and consumers.

This report intends to present a perspective focusing on the Digital Product Passports and data standards which will weave through this framework and act as crucial technological enabling mechanisms.

The mechanisms by which DPPs may support a circular economy have been noted and explored by various institutions, even before the identification of DPPs as a solution by regulators.

[1] See more: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal
[2] See more: https://www.weforum.org/projects/circular-economy
[3] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190918-2
[4] European Commission, 2020. Circular Economy Factsheet. DG ENV.F1 – DEC. 2020. Available from: https://ec.europa.eu/environment/enveco/pdf/FACT_SHEET_iv_Circular_Economy.pdf
[5] See more: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
[6] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_420
[7] European Commission, 2022. Proposal for a regulation of the European Parliament and of the Council on ecodesign for sustainable products, amending regulation (EU) 2019/1020 and repealing Directive 200/125/EC.

While, on the conceptual level, DPPs are an important enabler of the transition towards a circular and climate neutral economy, as well as towards the digital twin transformation, their actual impact will depend on the specific choices made during their implementation.

Data needs, as well as the cost-benefit of tracking data in the supply chain differ across both sectors and specific products. Even though the push for Digital Product Passports comes from the EU, supply chains are global, and without strong, structured cooperation among suppliers and other market players (often situated outside the EU), the introduction of circular economy solutions may become challenging for industry, with a disproportionate impact on SMEs. Managing robust packages of data about products across global supply chains may be significantly simplified when international, open standards for product identification, product data capturing and sharing are implemented.

Numerous experts consulted in the preparation of this report pointed to the fact that an obvious choice for an organisation that already fulfils the above-mentioned goals is GS1 – a global, not-for-profit standardisation organisation. GS1 has, over the past 50 years, empowered industry's digital transformation and supply chain automation, enabling digital commerce and popularising barcodes now considered to be ubiquitous with global retail. Constantly adjusting to the changes made by both the market and regulators, it is the most widely used system globally, especially in the fast-paced consumer goods industry.

As such, the GS1 standards system already has the potential to unlock globally-interoperable exchange of product data along global supply chains for circular purposes.

One of the first product passports has been proposed by the EU in the form of the Sustainable Battery Regulation which, under Article 65, introduces the concept of a "battery passport" for electrical vehicles and industrial appliances.[8] GS1 is looking into these challenges with the goal of engaging in sustainability and circularity, having already established global and sector-oriented data models and registries where product, location and entity data can be checked. They have also been developing cross-sector data semantics, in partnership with industry agents.[9]

This report focuses on providing an impact analysis of differing implementation models[10], including the full potential of the GS1 standards system for circularity in the EU. It covers five sectors: electric and electronics, batteries, food and beverages, packaging and textiles.

Ultimately, ongoing industrial investments will need to be made in the better structuring and management of product data, increased transparency along supply chains (as the new EU due diligence act demands), traceability data sharing across complex supply chain networks, and consumer rights (such as the right to repair). Additional investments are needed to complement the investments already being made in response to consumer demand for more ethical and greener products.

[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020PC0798
[9] https://www.gs1.eu/news/a-standards-based-knowledge-system-for-the-circular-economy
[10] Models align with differing implementation scenarios which are identified as possible and dependant on upcoming delegated acts and the final regulatory framework.

2

Reasons for change

Reasons for change

The objectives of the Digital Product Passport (DPP) in circularity are to support sustainable production, to enable digital transition, to provide new business opportunities to economic actors, to support consumers in making sustainable choices and to allow authorities to verify compliance with legal obligations.[11]

The passport aims to allow key supply chain actors to identify the most important information about the makeup of each product and to reuse it / treat it appropriately at waste management facilities in order to recover valuable materials and, ultimately, minimise CO_2 emissions.

The Digital Product Passport is a solution that is meant to coordinate and simplify data processes. Supported by global open standards and the right tools, it has the potential to:

- Limit data disruption along supply chains;
- Facilitate the sharing of data and product information and enable interoperable data;
- Bolster economic growth as a result of the opportunities unlocked by wider access to data on product use, origination and supply chain characteristics;
- Support consumers in making sustainable choices by improving transparency; and
- Enable superior management of products and waste, through the technological empowerment of organisations to create, implement and control circular economy solutions.

The European Commission has formally introduced the Digital Product Passport concept with the publication of the proposed ESPR.

This proposes a gradual deployment of DPPs for the broadest possible range of products, presently capturing all goods and components, to the exclusion of only 7 categories (including food, feed and medicinal products), although this scope could possibly be modified.[12]

[11] European Commission, 2021. Digital Product Passport: sustainable and circular systems.
[12] European Commission, 2022. Proposal for a regulation of the European Parliament and of the Council on ecodesign for sustainable products, amending regulation (EU) 2019/1020 and repealing Directive 200/125/EC.

2.1 Changes brought by Digital Product Passport

Digital Product Passports will unlock a number of opportunities for consumers, industry, global commerce and the planet.

Impacts on Product Design

A product's environmental footprint data can influence the composition of a product already at the design stage, limiting the usage of precious and rare resources, since manufacturers will know that each product passport will record whether the materials used for its production are of recycled origin. At the same time, DPPs can better facilitate ecodesign efforts, aiming to produce more sustainably and to use materials that can be recycled. Traceability and reliable data about how products have been used (and for how long) could help influence the creation of products optimised for their expected usage. This data can also improve logistics and enhance the 'just-in-time' management of products and resources (e.g., regarding maintenance services).

Consumer Empowerment

Another important vector through which a DPP can catalyse a truly circular economy is the empowerment of the consumer. Consumers are becoming increasingly conscious of the environmental impact of products, with surveys showing an increasing willingness to pay for sustainable products and that eco-labels affect buying decisions. However, there remains an information asymmetry between producers and consumers. There is a barrier to accessing information on daily purchases and few consumers will have the time to research or investigate the sustainability of various companies and products (even in the cases when such information is reported). Implementation of DPPs will have a meaningful impact on consumer empowerment. With increased transparency enabled by a DPP, economic operators both from inside and outside the EU will be incentivised to make changes – or potentially accept lower sales.[13]

Data Credibility

Since a DPP will likely involve direct ties to certification providers (who will themselves likely need to interface with the DPP and upload relevant data), consumers may find the certificates to be more credible and trustworthy. Likely, they will also be less concerned that eco-labels and sustainability certificates are out of date or unverified – rather than being printed on packaging, consumers will "see" the connection to the certification agencies and perhaps even have direct access to certificates.

New Business Creation

The Digital Product Passport scheme can also influence the creation of new circular businesses, as underserved markets can be stimulated by access to new data about products. Furthermore, the proposed ESPR is expected to boost jobs in the reuse and repair sectors; according to estimates made by the European Environmental Bureau, there is the potential to create an additional 300,000 jobs[14].

Post-Consumption

Recyclers can also leverage data obtained from a Digital Product Passport. Having access to detailed data about the material composition of each product can help avoid downgrading resources. Also, the recycling processes will deliver reliable data about what and how much of each component was recycled.

Consumer Engagement

The DPP will also provide producers with a new channel/medium through

[13] Deloitte, 2021. Climate Sentiment Index.
[14] https://eeb.org/work-areas/resource-efficiency/waste-recycling/

which to communicate with the consumer and convey greater volumes of relevant data where previously they might have been restricted by distributors and constrained by label sizes. For instance, the Digital Product Passport could be a way to provide additional usage instructions, ensuring product safety. It can also contain recycling and dismantling instructions, leading to a higher probability that an item can be repaired and resold by the producer or used for parts. Traceability enforced by a Digital Product Passport can also be highly effective in the fight against counterfeiting, which will be especially valuable for luxury goods producers and their consumers.

The DPP will also find wider utility benefitting consumers and businesses, such as through processes enabling highly targeted recalls without disrupting wider global value chains. Producers of electronics, for instance, might find significant savings and avoid creating unnecessary waste by being able to accurately trace specific faulty batches.

Increased Sharing of Data

It is important to underline an additional benefit of the ESPR, which is the digitalisation of product data. A requirement to have a digital product passport pushes producers to better structure and improve the quality of their data, leading to an easier exchange between stakeholders in a complex value chain.

Improvements in Data Quality

Better data quality can also be useful, both to governments and producers, in meeting targets set by the European Union and enforced at the producer level to improve collection and recycling of waste. For governments, the DPP can also play a valuable role in standardisation and potentially decrease the number of necessary audits. The Passport will also enforce better data structures for supply chains which, in the long run, will bring significant economic gains (for example, by improving efficiency of resource and supply chain management).

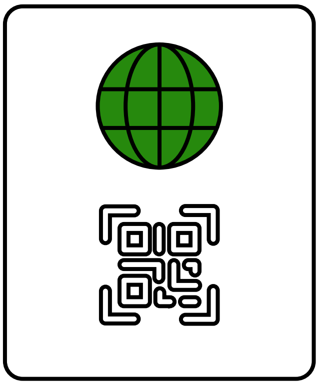
Summary

Traceability and reliable data about how products have been used (and for how long) could help influence the creation of products optimised for their expected usage. This data can also improve logistics and enhance the 'just-in-time' management of products and resources (e.g., regarding maintenance services).

There are benefits to be found for virtually anyone that is involved in any part of the product lifecycle, as well as those treating it at the end of its life or giving the product multiple lives. The side benefit of having clean and standardised data that is easily exchanged makes the argument for introduction of a DPP even more attractive.

The technological infrastructure required for the Product Passport is not yet fully decided, however, and regulators may leave some of these decisions to the market. It remains envisioned that the Passport will be presented to end users in an easily accessible form. Because of existing uncertainties, this report focusses on qualitative and as far as possible quantitative, analysis.

The quantification of all changes brought by the introduction of a Digital Product Passport is somewhat hindered, for several reasons. Firstly, the form of the passport and the shape of regulations implementing it presently remains dependent on the delegated acts, which are yet to define important parameters. These are key variables that fundamentally impact analysis. Secondly, the passport constitutes a paradigm shift in supply chain, resource, and waste management, as well as in data transparency both in the market and along the value chain; in the construction of models, there are few existing analogues which can provide credible or appropriate baselines from which one can extrapolate. This is compounded by regulatory uncertainty and also by the sheer scale of the project and its comprehensive scoping, a reality which will affect thousands of businesses across many differing sectors. When dealing with such large ecosystems and world markets, miniscule adjustments to input variables may translate into vast shifts in output values. Even with a large margin of error, any predictions or estimations would not be robust, and might suffer in credibility. However, it is important to describe the qualitative gains that are to be expected by implementing the pro-posed ESPR.[15]



[15] European Commission, 2022. Proposal for a regulation of the European Parliament and of the Council on ecodesign for sustainable products, amending regulation (EU) 2019/1020 and repealing Directive 200/125/EC.

3 The EU Circular Economy landscape in sectors included in the Circular Economy Action Plan

The EU Circular Economy landscape in sectors included in the Circular Economy Action Plan

To achieve the ambitious goals set by the EU, certain enabling tools are required. To unlock the full benefits of a Digital Product Passport scheme, there needs to be a proper structure to identify, capture and share product data across complex global supply networks and with relevant stakeholders in a secure and efficient way.

Product data standards are necessary to providing an adequate infrastructure for the introduction of DPPs. A deeper analysis of differing scenarios for implementation of such a system is described in the final chapter, though to adequately build out the context of this report, it is important to first characterize the current state of circularity in the sectors covered herein. As the data shows, despite EU targets for the collection and recycling of consumed products, there are:

- Member States where those levels are still not being met;
- A few sectors where the targets are not yet set and the availability of data is limited.

In addition, we are also taking into account the fact that circularity implies a new business model including not just collection and recycling but also capturing and disclosure of information about chemicals substances of high concern, CO_2 emissions, due diligence and origin of raw materials data.

Our assumption is that Member States and sectors included in the Green Deal could particularly benefit from introduction of a DPP.

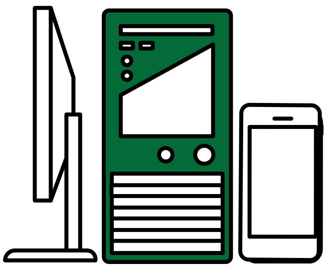
However, each sector has its own characteristics and barriers and, as such, is analysed and presented individually in the following subsections.

3.1 Electrical and Electronic Equipment (EEE)

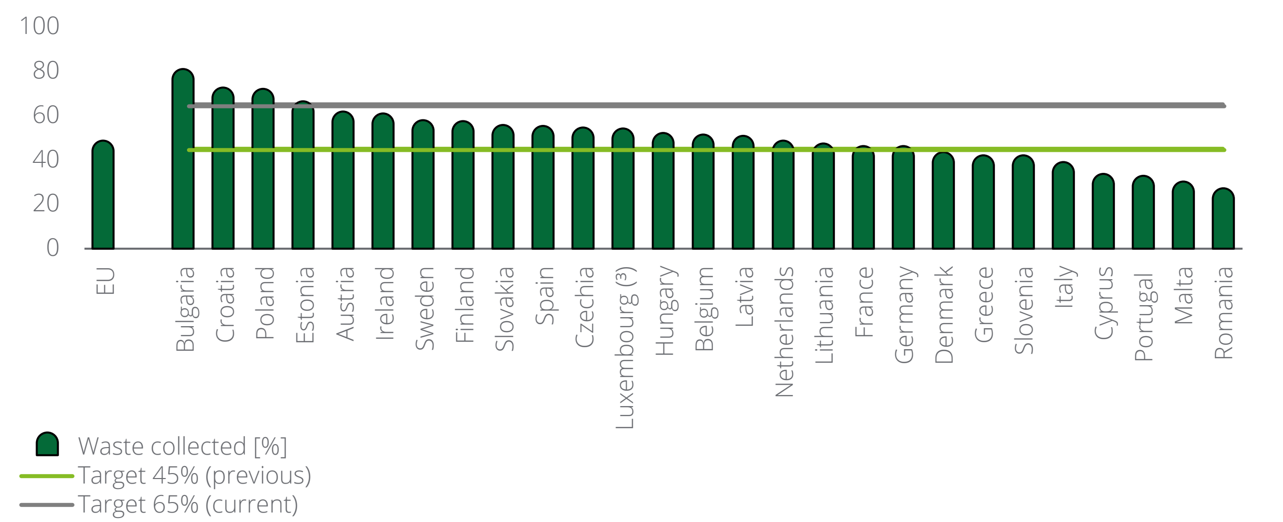
As the European Commission[16] points out, electrical and electronic equipment represent the fastest growing sources of waste in the European Union. These products often contain hazardous substances that can contribute to land contamination, ground water pollution and pose health risks to consumers. Electronics also contain rare-earth elements (REE) which are expensive and are often associated with environmentally-damaging extraction processes.

Circular solutions are not only important financially (as a means of recovering valuable resources – reducing the demand for expensive imports of virgin REE) but, through demand reduction, will also contribute to environmental protection.

The amount of EEE placed on the market in the EU grew from 7.6 million tons in 2011 to 8.7 million tons in 2018. On the other hand, the collection of e-waste (WEEE) in 2018 was estimated at 8.9 kg per inhabitant and amounted to a 47% collection rate, with only three Member States already meeting the new target of a 65% collection rate which came into effect in 2019 (the current reference year utilised by Eurostat).



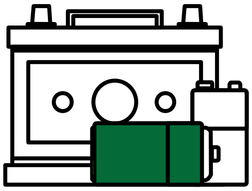
Collection rate for WEEE, 2019 [%]



Source: Eurostat

[16] European Commission, 2022. Waste from Electrical and Electronic Equipment (WEEE). Available from: https://ec.europa.eu/environment/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en

3.2 Batteries and accumulators

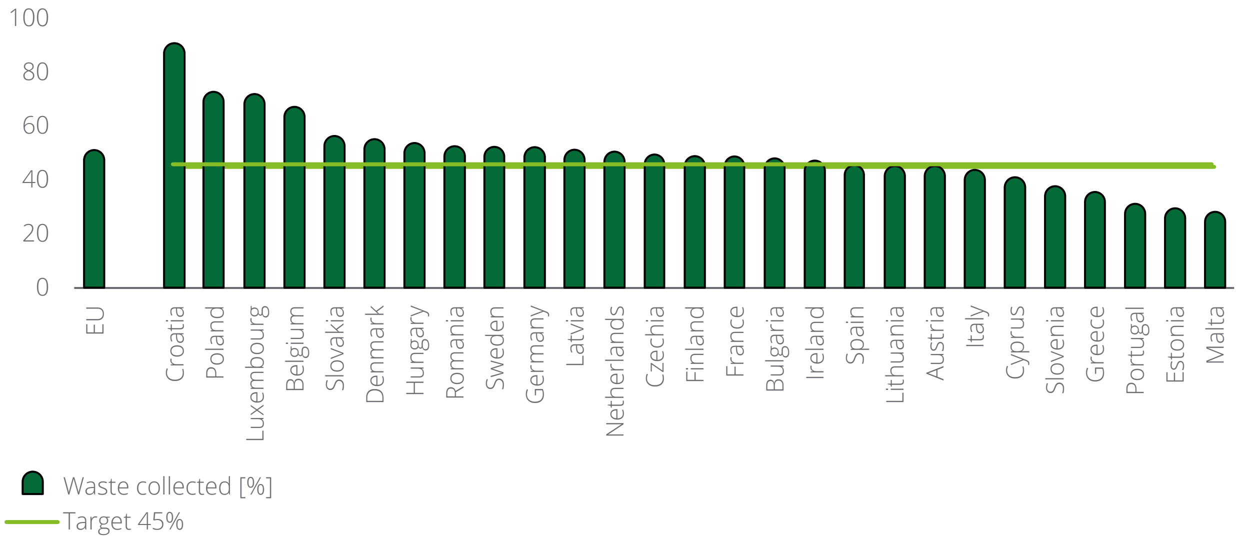


Batteries and accumulators play an essential role to ensure that many day-to-day products, appliances and services work properly. They are an indispensable energy source in our society. Global battery demand is expected to grow by 25% annually to reach 2,600 GWh in 2030. Batteries also play an increasingly important role in decarbonising transport through electrification and enabling the shift from combustion engines to low-emission electric vehicles. It is estimated that batteries can fundamentally reduce greenhouse gas (GHG) emissions in the transport and power sectors by approximately 30%[17].

In 2019, nineteen of the EU Member States reached a collection rate of portable waste batteries of 45% or more[18], which is a similar collection level to e-waste.

Whereas the Batteries Directive focuses on the end-of-life stage of batteries (with only limited provisions relevant to the production or use phases), the EU Sustainable Batteries Regulation (SBR) aims to ensure that batteries placed on the EU market are sustainable and safe throughout their entire life cycle – a goal aimed at promoting the production of green, sustainable batteries in Europe. The use of new IT technologies, notably the Battery Passport and interlinked data space, will be key for safe data sharing and will increase transparency across the battery market. Because of its potential, the sector has been prioritised by the EU and its requirements overlap with the Digital Product Passport proposed by the European Commission Action. Even though in terms of second life and DPP, the SBR currently focuses on industrial and electric vehicle batteries, considering that the ESPR seeks to capture the broadest possible scope of products, it is expected that all batteries will eventually fall under the regulation's requirements for ecodesign and DPPs. Another point supporting the idea that consumer batteries could fall in the scope of DPPs is that the proposed ESPR gives packaging as an example of upcoming product-specific regulation and, being sold in packs, consumer batteries are likely to be included for DPP.

Collection of portable batteries and accumulators, 2019 [%]



Source: Eurostat

[17] A Vision for a Sustainable Battery Value Chain in 2030 Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation, Global Battery Alliance, 2019
[18] Collection rates are as a ratio of the weight of the collected batteries in a reference year divided by the average of the weight of the batteries sold during the reference year and the previous two years.

3.3 Food waste

Even though the recently published Proposal for Ecodesign for Sustainable Products Regulation exempts the food sector from the scope of products[19], it has been included in the analysis for a number of reasons. Firstly, the proposal for a legislative framework for sustainable food systems (FSFS) is one of the flagship initiatives of the Farm to Fork Strategy and it is expected to be adopted by the Commission by the end of 2023. Its goal is to accelerate and make the transition to sustainable food systems easier. It will also have as its core objective the promotion of policy coherence at EU level and national level, mainstream sustainability in all food-related policies and strengthen the resilience of food systems.

Secondly, as mentioned above, since the proposal captures packaging in its scope, it would be difficult to imagine introduction of product passports only for the packaging of food products and not the contents. Finally, the food sector is considered as a key value chain in the Circular Economy Action Plan[20], as well as being listed as a priority product category for the circular economy in European Commission's document "Sustainable Products in a Circular Economy"[21].

Food waste is an issue of importance to global food security and environmental governance, directly linked with impact on the:

- environment (e.g., climate change, energy, water)
- economy (e.g., resource efficiency, increasing costs, consumption, waste management, commodity markets)
- society (e.g., health, equality).

The EU and its Member States are committed to meeting the UN Sustainable Development Goal target to halve food waste at the retail and consumer level by 2030 and reduce food losses across production and supply chain networks.

This journey involves both the Circular Economy Action Plan and the Farm to Fork Strategy for a sustainable food system. Through the Farm to Fork Strategy, the EC will propose legally binding targets to reduce food waste across the EU by the end of 2023.

To support all stakeholders in meeting this target, the EU Platform on Food Losses and Food Waste was established in 2016.

Some countries have already taken actions, such as policies and activities at the national level that aim to mobilise activities against food waste, but there is a long way to go.

[19] European Commission, 2022. Proposal for a regulation of the European Parliament and of the Council on ecodesign for sustainable products, amending regulation (EU) 2019/1020 and repealing Directive 200/125/EC.
[20] Circular economy action plan (europa.eu)
[21] https://ec.europa.eu/environment/pdf/circular-economy/sustainable_products_circular_economy.pdf

3.4 Textiles

In the EU, clothing, footwear and household textiles are the fourth highest (or fourth worst-ranked) category for use of primary raw materials and water (after food, housing and transport). This sector is also the second highest for land use and the fifth highest for greenhouse gas emissions[22].

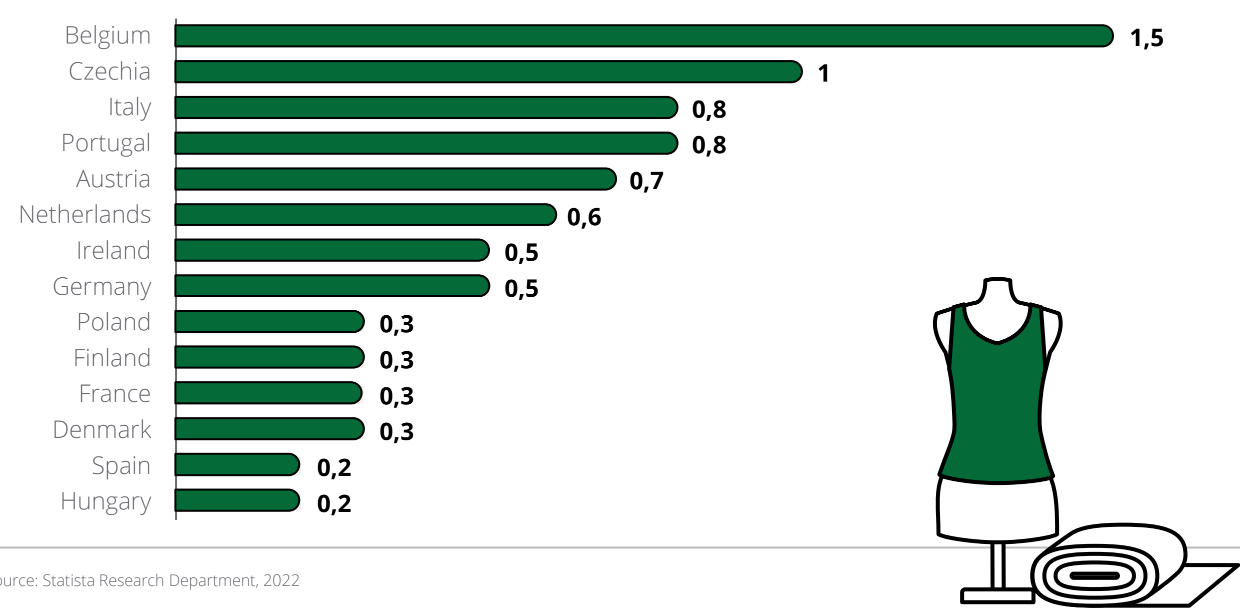
Recently, the European Commission identified textiles (apparel and fabrics) as a priority product category for the circular economy and issued a new sustainable and circular textile strategy.

The Commission will introduce clearer information on textiles and a digital product passport, establish a common methodology to report on reuse and consider setting specific targets for the reuse and recycling of textile waste by the end of 2024. This will likely involve producer responsibility and take-back schemes.

In 2017, 7.4 kg of textiles per person was produced in the EU, while consumption amounted to nearly 26 kg[23], which means that over 18 kg of textiles (per person) were imported from outside regions. In European countries, various players are involved in the collection of used textiles and textile waste: charitable and commercial collectors, municipalities, public or privately owned waste companies, clothing brands / retailers, or a combination of these. In many countries, municipalities play a role in used textile collection. This role can be hands-on or related to the setting of frameworks. By diverting textiles from mixed waste to separate collection streams, they can reduce waste collection and management costs, as well as meet their own environmental targets. However, no overall data could be found for separate collection rates for textiles across the EU.

The aim of the EU initiative is to set in place a comprehensive framework to create conditions and incentives to boost the circularity, competitiveness, sustainability and resilience of the EU textile sector. Consideration is paid to sustainable production, sustainable lifestyles, the presence of substances of concern, improving textile waste collection and recycling.

Yearly total quantity of recycled textile waste per person in the EU by country (2016) [kg/capita]



Source: Statista Research Department, 2022

[22] Paving the way for a circular economy: insights on status and potentials, EEA Report No 11/2019
[23] Ibid.

3.5
Packaging and Packaging Waste

The final sector of focus is packaging, which is used in all of the previously mentioned sectors. It also has dedicated EU legislation – being the Packaging and Packaging Waste Directive (94/62/EC). The Directive sets out recycling targets and contains measures designed to prevent the production of packaging waste.

The Commission is currently assessing options to review the Packaging and Packaging Waste Directive with a view to (among other aims) improving design for reuse, promoting high quality recycling and strengthening enforcement of the legislation.

This review will contribute to aligning with the objective of the European Green Deal, as well as the new circular economy action plan, ensuring that "all packaging on the EU market is reusable or recyclable in an economically viable way by 2030".

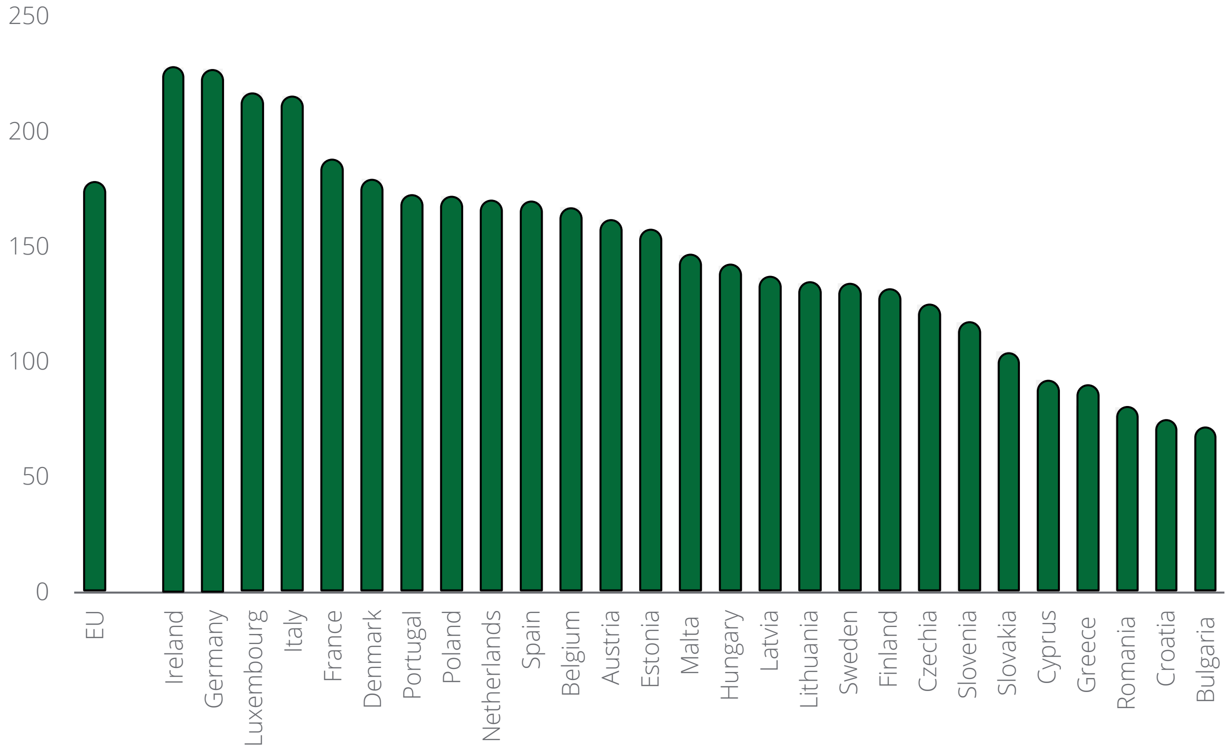
Moreover, this directive establishes that, by the end of 2024, EU countries should ensure that producer responsibility schemes are established for all types of packaging. These schemes should help incentivise packaging that is designed, produced, and commercialised in a way that promotes packaging reuse and high-quality recycling and minimises the impact of packaging and packaging waste on the environment. In addition, the Directive on Single Use Plastics assumes additional targets for PET bottle collection, which should reach 77% by 2025 and 90% by 2029.

Table 1. Percentage of packaging waste subject to recycling versus total amount of packaging supplied onto the market

	by 2025	by 2030
Packaging in total	**65%**	**70%**
Plastics	50%	55%
Wood	25%	30%
Steel	70%	80%
Aluminum	50%	60%
Glass	70%	75%
Paper and cardboard	75%	85%

The total amount of packaging waste generated and recycled is compiled from across all packaging materials – including glass, paper / cardboard, metal, plastic, wood and others.
In 2019, the total volume of packaging waste generated in the EU was estimated at 79.3 million tons, which constitutes over 20% growth in 10 years. Technological innovation, e-commerce and growing consumption are among the reasons for the remarkable growth of consumer packaging. In 2019, on average, 177.4 kg of packaging waste was generated per capita in the EU. This quantity ranged from 74 kg per capita (in Croatia) to 228 kg per resident (in Germany and Ireland).

Packaging waste generated (2019) [kg/capita]



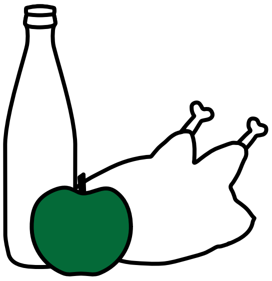
Source: Eurostat

Overall, the required target of 55% recycled packaging waste was met by almost all countries.

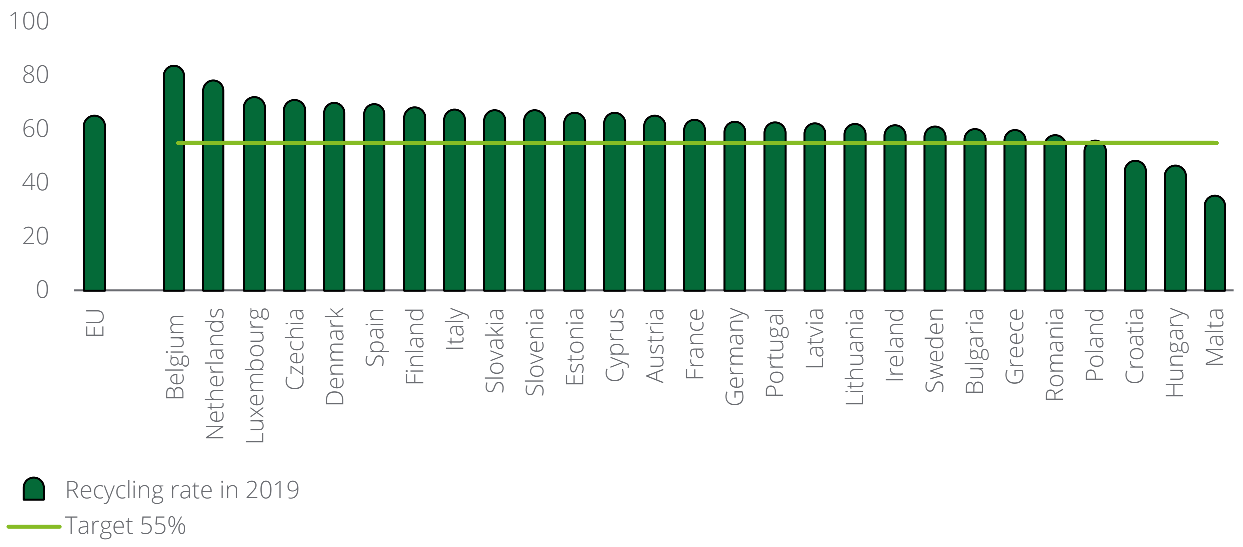
Belgium had the highest recycling rate, at 84.2%.

However, Member States often have varying methods of waste treatment, with some countries implementing extensive, at-home sorting systems. Some countries have Extended Producer Responsibility schemes or taxes on industries for the packaging that they are placing on the market while others have additional deposit schemes that shift more burden onto consumers.

To ensure effectiveness, governments need reliable data to identify manufacturers that are most responsible for packaging waste. A DPP is a clear example of information-oriented digital infrastructure which could provide such data and directly contribute to effective waste management through interfacing with waste management models. International, open standards have proven to be efficient if used to enable DRS (e.g., in Norway, Denmark and Sweden).[24]



Recycling rate of packaging waste (2019) [%]



Source: Eurostat

[24] https://www.gs1uk.org/insights/news/going-circular-deposit-return-schemes-and-the-role-of-gs1-standards

Summary

Looking at the statistics and estimations, high-value sectors tend to consistently generate less waste, while those producing outputs with lower value (such as food and packaging) create drastically higher volumes. However, the composition or ingredients of such products is also drastically different and the underlying value varies, especially after first use or consumption.

Tools are required to achieve the ambitious goals set by the EU. To fully unlock the benefits of a Digital Product Passport scheme, there needs to be a proper structure to identify, capture and share product data across complex global supply networks and with relevant stakeholders in a secure and efficient way.

Product data standards are necessary to providing an interoperable data infrastructure for introduction of DPPs. A deeper analysis of differing scenarios for implementation of such a system is described in the final chapter.

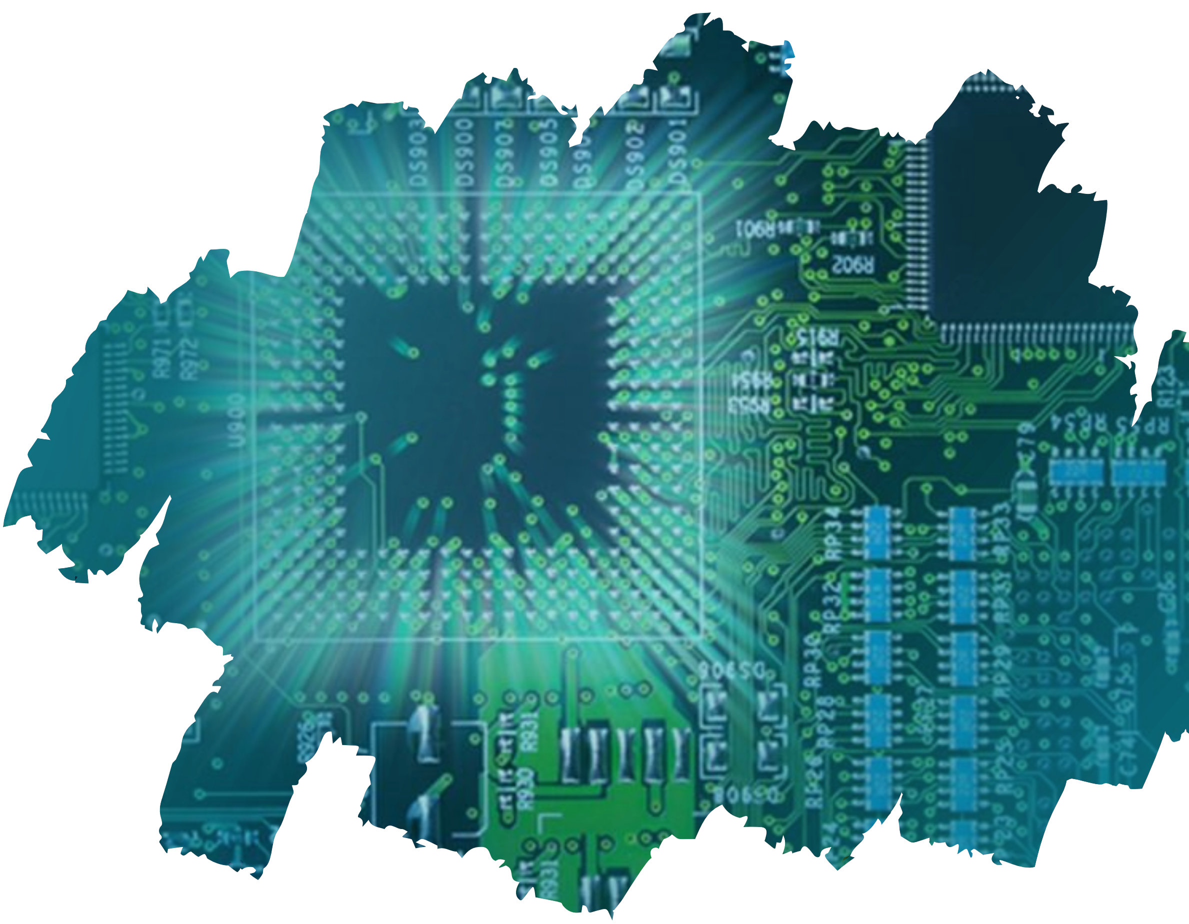
Table 2. The amount of waste generated in analysed sectors per capita, 2019

Consumer electronics and household appliances[25]	Batteries	Food and beverages	Textiles[26]	Packaging
16 kg	15 kg	173 kg	11 kg	177,4 kg

Collection and recycling efforts need to be multiplied, as the Member States in most cases are not meeting the targets set by the EU (if those targets are even firmly set at all). A way to close existing information gaps is to use credible data and increase recycling efforts is enhanced product identification enabled by a Digital Product Passport. The possibility to identify each product, its raw constituent materials, composition and associated entities / locations can immensely increase the effectiveness of recycling methods. Aided by Digital Product Passports, waste can be sorted according to material and mixed waste can be more readily identified and recycled together, without lowering the quality of processed materials. This is especially important in the recycling of plastic, but can also be of particular value to textiles and electronics.

[25] Estimation of European Parliament
[26] Estimation of European Environment Agency

4 Standardisation



Standardisation

There are various standardisation bodies across the globe which can be categorised by their geographical reach – global, European, national. However, this study focuses on the impact of international, open product data standards on circularity, whose criteria are mostly fulfilled by GS1 standards.

Nevertheless, a report considering the impact of standards on circularity in the consumer goods sector should also acknowledge what is perhaps the best-known standardisation organisation – ISO (International Organization for Standardization). Both ISO and GS1 provide a variety of standards that simplify the everyday operations of numerous companies globally. International standards, as the ones developed by ISO and GS1, bring benefits for:

Industry:

- Become more competitive by offering products and services that are accepted globally
- Lower transaction costs
- Raise profits by offering products with increased quality, compatibility, and safety
- Reduce costs by not reinventing the wheel and using available resources better
- Benefit from the knowledge and best practice of leading experts around the world.

Regulators:

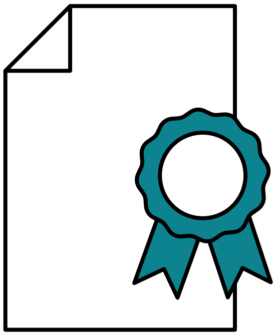
- Harmonise regulations across countries to boost global trade
- Increase credibility and trust throughout the supply chain
- Make it easier for countries to outsource and specialise.

Society:

- Wider choice of safe and reliable products and services at competitive prices
- Best practice and concerted action at the organisational level to practically address global challenges like climate change and sustainability.

ISO has dedicated significant efforts to sustainability and continues to support changes that are enumerated in the context of this report. Many GS1 standards have been adopted by ISO and, in some cases, ISO standards originate from the GS1 community, which further exemplifies the need to analyse GS1's relevance and potential impact, as it provides the most widespread supply chain standards used every day by millions of people (and systems) globally. GS1, unlike other international standardisation bodies, invests heavily in facilitating industry implementations worldwide.

GS1, as a global not-for-profit standardisation body, develops and maintains standards for product, location and entity identification, as well as standards for the capture and exchange of product data. This means that GS1's focus is well-defined and precise. This report calculates the impact of using GS1 standards for green and digital product passports.

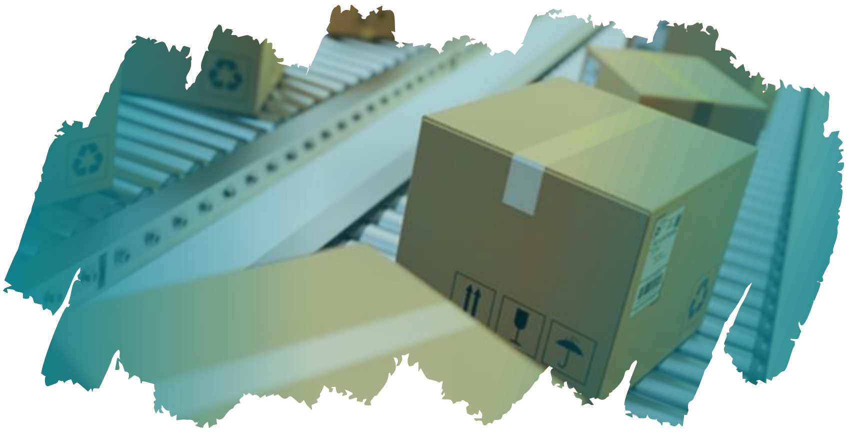


4.1
Increasing demand for identification of products, locations, and entities

The principal conclusion arising from the analysis of industries herein is that there exists consumer, industrial, and regulatory needs for an identification system that supports advanced and multiple use cases.

Such a system must identify locations, entities, product components, raw materials, and environmental footprint (including CO_2 and packaging) if we wish to meet circularity targets. Many data points are still missing or are limited today, which is an obstacle to properly assessing the shift from linear to circular models – a crucial gap which can be bridged by a DPP scheme.

It must be stated that the identification of products and packaging can be done in various ways. Companies can have their own proprietary method for identification, but there are also global identification standards that are already widely used.



The best-known standard is the barcode, which has been used to identify items for over 50 years and which is scanned more than 6 billion times each day around the world.

To fully understand the challenge of having an identification system for circularity, it is crucial to describe the efforts that were taken to develop the system that we have today, and what parts of this existing system could be used for the extended needs of circularity.

Historic background of the barcode

GS1 is an organisation that stands behind the ubiquitous and widespread usage of what is known worldwide as the barcode, deeply rooted in the retail sector. GS1 traces its roots to 1971, when U.S. industry leaders agreed to collaborate under the Ad Hoc Committee on a Uniform Grocery Product Code (later changed to Uniform Code Council, or UCC), to jointly implement a unified code which could serve to identify grocery products.

What emerged was the Global Trade Item Number (GTIN), also known in the US as the UPC (Universal Product Code). On 26 June 1974, a packet of chewing gum became the first barcoded product to be scanned in store. After the UCC successfully established a system in the United States, a similar non-profit association was formed in Europe. It was created in 1977, and took the name of European Article Numbering Association, based in Belgium.

Figure 1. GTIN

GTIN 5 901234 569009 >

In collaboration with UCC, this association extended the system with the introduction of the European Article Number (EAN), going from 12 to 13 digits and thus expanding the capacity of the system to serve global commerce.

In 2002, the UCC joined EAN International as a member organisation, and in 2005, GS1 was officially launched as the merger of both organisations, providing a globally compatible system[27] that is now directly supported by Member Organisations in 116 countries around the world.

GS1 suite of standards

The GTIN identifier was designed for open supply chains from the very beginning and is currently the most widely used and accepted standard for product identification globally. It introduced a system that streamlined various activities, both in store (leading to reduced transaction times) and across logistics and supply chain networks. It initiated a transformation of nature of commerce and allowed businesses to digitalise numerous processes[28].

As the GTIN is a globally unique identification number, it is designed to identify any products or service that is priced, ordered, or invoiced at any point in the supply chain[29].

Even though such codes are mostly associated with an individual product, the codes can be used to identify any product grouping, whether a product pack, a case, or a pallet. Batches can be further identified with the help of the batch or lot number, and other data such as an expiry date.

For the context of this report, is important to note that individual items can also be identified using a GTIN with the addition of a serial number (SGTIN).

[27] https://www.gs1.org/docs/barcodes/GS1_General_Specifications.pdf
[28] Celebrating 50 years of digitalisation in commerce – and focusing on the next 50 | GS1
[29] https://www.gs1.org/docs/idkeys/GS1_GTIN_Executive_Summary.pdf

Once a product is assigned with GTIN by a company, the GTIN provides a common language for all other entities, serving to both uniquely identify the item and easily exchange data about it. A GTIN can also be used to identify items online (for example in listing marketplaces, catalogues, invoices, or web pages to optimise search for consumers).

However, a GTIN is one of the many standards that GS1 governs. The standards are divided into the three main functions, namely: identification, data capture, and data sharing. GTINs are the most known identification standard, but GS1 has developed others for different purposes, for example to identify locations, entities and assets. GS1 identification standards are also known as ID Keys (see table below).

This suite of standards allows for the identification of various types of entities across a global supply chain net-work, which may be used by an information system to refer unambiguously to a real-world entity. ID Keys can be used to identify not only products, but also parts and the lifecycle of the product (starting as early as the design process and ending with disposal). Some examples of organisations and locations that can be identified with a Global Location Number in the circularity context are primary producers (farms, mines, forest lots, etc.), processing and packing facilities, warehouses, distribution centres, retail stores, repair shops, buildings, etc. The keys also cover logistics units (including returnable assets like pallets), documents, and coupons. The basis upon which all identification standards are based is a Company Prefix[30], which ensures global interoperability and simplicity of administration.

Table 3. GS1 ID Keys

ID Key	Identifies	Example
Global Trade Item Number (GTIN)	Products and services	Can of soup, chocolate bar, music album
Global Location Number (GLN)	Parties and locations	Companies, warehouses, factories, stores
Serial Shipping Container Code (SSCC)	Logistics units	Unit loads on pallets, roll cages, parcels
Global Returnable Asset Identifier (GRAI)	Returnable assets	Pallet cases, crates, totes
Global Individual Asset Identifier (GIAI)	Assets	Medical, manufacturing, transport and IT equipment
Global Service Relation Number (GSRN)	Service provider and recipient relationships	Loyalty scheme members, doctors at a hospital, library members
Global Document Type Identifier (GDTI)	Documents	Tax demands, shipment forms, driving licenses
Global Identification Number for Consignment (GINC)	Consignments	Logistics units transported together in an ocean container
Global Shipment Identification Number (GSIN)	Shipments	Logistics units delivered to a customer together
Global Coupon Number (GCN)	Coupons	Digital coupons
Component/Part Identifier (CPID)	Components and parts	Automobile parts
Global Model Number (GMN)	Product model	Medical devices

[30] https://www.gs1.org/sites/default/files/docs/idkeys/gs1_id_keys_reference_card.pdf.pdf

Data capture

ID Keys in themselves do not carry a lot of information, as the popular 13-digit format can only allow for product identification. When these ID Keys are used in connection with standards for data capture (such as barcode), machines access additional information, such as expiry dates. Such information is automatically captured and carried directly on physical objects, usually in the form of a printed label. There are two types of GS1 data capture standards: barcodes and Radio-Frequency Identification (RFID), out-lined in Figure 3. Barcodes can be further divided into 1-dimensional (1D) and 2-dimensional (2D).

A 1D code is popularly known as a barcode, and it is a series of lines used to store text information such as product type, size, and colour.

There are also more capable 2D codes, such as QR code or a Data Matrix, that can carry even more data in a compact size.

ID Keys can also be encoded using Electronic Product Codes (EPC) connected to Radio-Frequency Identification (RFID) tags. This technology allows information to be obtained without direct contact with the pro-duct. Most commonly, it is used for durable products (for example textiles).

Figure 2. GS1 Standards for data capture

Box 1. GS1 Digital Link

Another recent development, GS1 Digital Link, allows companies to enable connections to all types of business-to-business and business-to-consumer information via the web. It is an open standard that de-fines how identifiers (such as GTIN or GLN) can be encoded in a URL, in turn allowing a 2D barcode to unlock supply chain efficiency, enable ubiquitous access to data, and enable direct consumer engagement. As such, Digital Link can be implemented not only for QR codes or RFID tags, but also for the traditional 1D barcode, meaning that the final product can still be labelled with the barcode it has had for years, while the information behind it can be significantly expanded.[31]

Figure 3. GS1 Digital Link functionality enables supply chain efficiency, access to data, and consumer engagement

[31] https://www.gs1.org/standards/gs1-digital-link

4.2 Data sharing

In the case of data sharing, GS1 has defined and maintains three categories of standards: Master Data, Transaction Data and Event Data.

Master data are attributes of an entity that are static, meaning data that is not changing (or at least very rarely). For a trade item class, for example, master data might include the trade item's dimensions, description, nutritional information (in the case of a food product), and so on. For a legal entity, master data might include the name of the organisation, its postal address, geographic coordinates, contact information, and so on. Master data provide the information necessary for applications to understand trade items and entities and to process them appropriately in business processes.

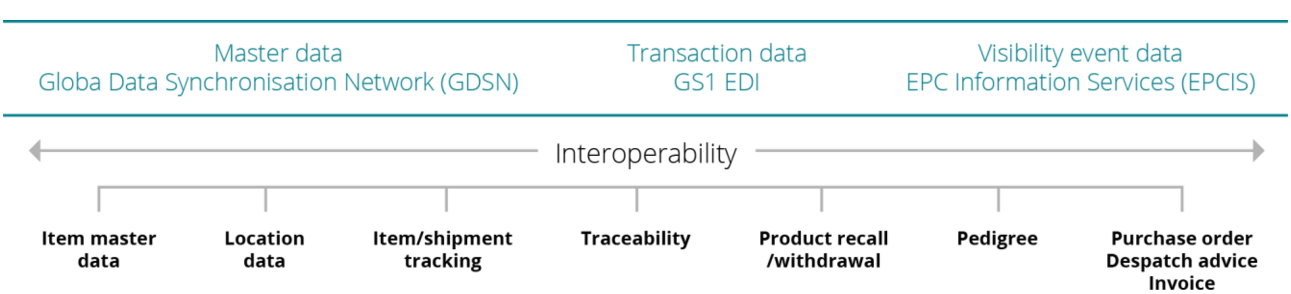
Transaction data refer to information required to support a collaborative business process shared bilaterally between organisations. Often these are functionally the same as their namesake paper documents, such as purchase order and invoice. Transaction data is consumed by software applications, not directly by humans. This means that the GS1 design principles include rules such as only exchanging coded rather than clear text information and that master data should be aligned before exchanging the transactional data.

Event Data are records of the completion of business process steps in which physical or digital entities are handled. Where Transaction Data can confirm legal or financial interactions between trading partners, Event Data can confirm the carrying out of a physical process or a comparable digital process. Examples of processes that may be the subject of Event Data include affixing of identification to a newly manufactured object ("commissioning"), shipping, receiving, movement from one location to another, picking, packing, transfer at point-of-sale, and destroying. The power of event data ex-change standards is that such data is at the core of how to document the myriad transformations that occur in the manufacture, transport, sale and disposal of products.

Master data, electronic transaction data, and event data are enabled by GS1 standards, and use GTIN or another GS1 identification key to refer precisely to a specific item, or other real-world entities[32]. GS1 provides a complete standardised language for the exchange of each of these kinds of data.

There are also established mechanisms that enable the actual exchange of structured, standardised data. Typically, the Global Data Synchronization Network (GDSN) would be used for master data, GS1 Electronic Data Interchange (EDI) for transactional data, and Electronic Product Code Information Services (EPCIS) for event data. See graphic below.

Figure 4. GS1 Standards for data sharing



[32] https://www.gs1.org/sites/default/files/docs/architecture/AG_Flyer_final.pdf

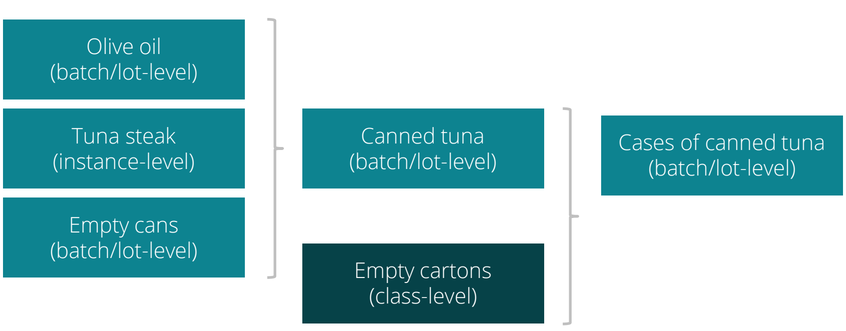
4.3
Traceability of products

During their journey from multiple suppliers and producers to final consumers, raw materials are collected and subjected to many steps before becoming a final product.

At each step, a set of raw materials or components, each identified with a GTIN, is turned into a new product with a new GTIN. This aggregation of data can be recorded at each step and shared with other supply chain participants using GS1 standards.

The graphic below contains a simplified example of multiple products, each identified at batch/lot level (using GTIN + batch number) or at class level (GTIN only), eventually aggregated into a final product.

Figure 5. Example of aggregation of raw materials into a finished product



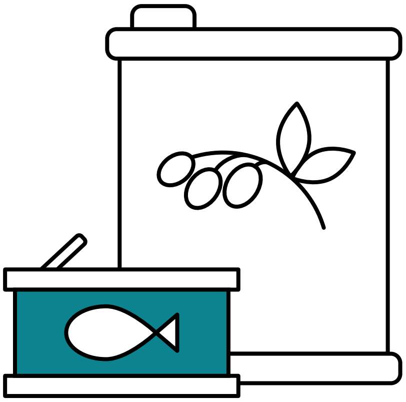
GS1 introduced a standard for this exact use – the GS1 Global Traceability Standard (GTS2). It introduces two key concepts for interoperable traceability:

1. **Critical Tracking Events** – the packing, shipping, transporting, that occur to the traceable object during its lifecycle
2. **Key Data Elements** – the elements of data that describe the actual instances of the Critical Tracking Events.

GTIN and GLN uniquely identify the objects (that are moving through supply chains), and the locations to and from which they travel. These Identification keys enable the connection of physical flows of goods with their corresponding data flows within a trading partner's processes, as well as across different trading partners' processes, as well as across different trading partners' processes.

When taken together, this system of standards enables the identification economic actors, of products and of locations, as well as the automated processing and sharing of information both between and across trading partners and regulators, which offers significant opportunity to address current gaps in the supply chain and enable circularity.

Product identifiers can be used to record the post-consumption actions of consumers (e.g., placing an empty can in a recycling bin) and can also be used to verify the packaging composition (such as type(s) of metal and coating used in the can's production in process steps that are much further upstream). If the product is identified at a batch level, it will be straightforward to assess the percentage of cans recycled – a principle which can be applied to other sectors.



A result of GS1 providing open standards is a global community that creates various initiatives to further facilitate deeper use of GS1standards. For example, GS1 also develops syntaxes, meaning a grammar that supports a hierarchical structure. The syntax of the string of characters is independent of the data carrier (it can be encoded in 1D barcodes, QR codes, Data Matrix codes and so on).

The global GS1 community has also created a 'syntax dictionary' that consists of a set of entries describing each currently assigned GS1 Application Identifier.

Another benefit of an established global community is the natural extension of other established standards, while avoiding duplication. For examples, the GS1 Web Vocabulary[33]was designed to extend the vocabulary for online definition of products, and has been created as a natural extension of schema.org stan-dards[34]. The cooperation between GS1 and schema.org allows the flow of ideas in both directions and functions to avoid duplication.

The information presented in this chapter is meant to provide readers with context of complexity and varied benefits that are related to usage of GS1 standards. However, to fully understand how GS1 standards fit together, it is recommended to visit GS1 System Architecture Document.[35]

[33] GS1.org/voc
[34] Schema.org
[35] https://www.gs1.org/standards/gs1-system-architecture-document/current-standard

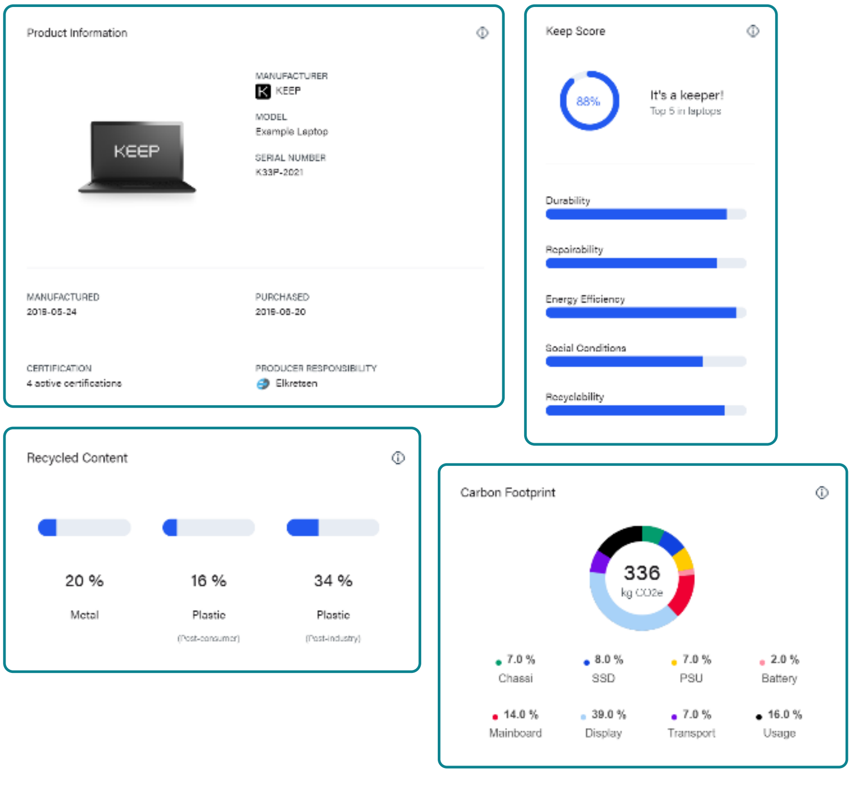
4.4
Industry projects parallel to Digital Product Passport

In the context of the circular economy landscape, it is important to mention examples of projects and initiatives that were initiated by the industry before the Digital Product Passport became a concept at the European Commission level.

One such example is the Keep project, which offers a traceability solution for electrical and electronic products, aiming to keeping them in a circular system. The project was funded by Sweden's Innovation Agency, and tracks all materials and components, unlocking the ability to better understand the origin of every product. The team working on the project was aware of the challenges of obtaining and managing information and, instead of creating a new standard for their purposes, the drivers of the Keep project collaborated with GS1 Sweden on information sharing and standardisation. Producers also understood the benefits of such an initiative, and with engagement and input from Lenovo, the project team was able to pinpoint what type of data is already available in the producer's systems. This unlocked the possibility to quickly understand existing and to focus energy on how these gaps might be filled (presented in the Keep prototype)[36]. The project also addresses concerns that much of the environmental data is not necessary for consumers, and the fact that consumers might not know how to utilise much of this data.

With the use of Keep, consumers are presented with a clear overview of a product in a way that data is neatly organised and assigned an overall "Keep score".

Figure 7. Example of information that could be provided to consumers



[36] keepelectronics.com

Another example that aims to fill the information gap in circularity is the R-cycle initiative. R-cycle is a cross-industry consortium, aiming to create a true cradle-to-cradle recycling system, all the while supporting the Digital Product Passport concept. In this system, data about packaging is provided by machines on the production line and is then shared further along the supply chain and be-tween companies. This initiative can provide reliable data about the levels of recycled plastic used in packaging – which is seen as a significant achievement. As with the Keep project, the R-cycle initiative also benefits from existing GS1 standards for identification and event tracking. The consortium decided to use GS1 standards because of market recognition, especially in the fast-moving consumer goods sector, as well because of existing data structures that enable a majority of the functionalities needed for R-cycle operation.[37]

Figure 8. Example of data shared in the R-cycle initiative

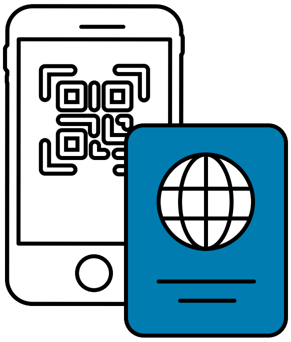
These projects, among others like the „Internet of food and farm project" (IoF 2020) financed by the EU under the Horizon 2020 funding programme[38] serve to demonstrate that global, open standards are being tested for circularity and that they can enable complex data structure like Digital Product Passport to be widely implemented and to also be beneficial for various organisations across a product's lifecycle. There are quantifiable benefits that a DPP can have on various aspects on the economy, with these being dependent on how such a scheme is to be implemented – this is explored further in the final chapter.

[37] https://r-cycle.org
[38] https://www.iof2020.eu

5 Impact calculation

Impact calculation

The net benefits of a Digital Product Passport (DPP) will heavily depend on implementation costs. On a macroeconomic level, a product passport will increase the productivity of the European economy, enabling the achievement of a circular economy through an efficient data-based mechanism.



The benefits, however, extend beyond just improving circularity in one region. Supply chains are global and complex, and to achieve more transparent, ethical, and green supply chains, it is recommended to take measures that will have impact globally. Increased traceability and availability of data will bring a new level of transparency in the marketplace, enhancing efficiency and enabling new business models.

The benefits of a well-designed product passport are extensive, including enhanced product safety and tougher counterfeiting resiliency.

Although this is presented in European Commission impact assessments, realising this potential requires front-loaded investment across global supply chain networks. A suboptimal process, the doubling of existing work, and competing / proprietary standards can increase the costs of implementing a product passport to the point where they may outweigh the benefits for several years. Such a situation would turn the early years of the scheme into an administrative burden that does not immediately demonstrate value for the ecosystem.

Many of these factors, however, can be mitigated or avoided by leveraging existing ISO standards and ubiquitous GS1 standards for product data identification, capture, and sharing of data.

Crucial information about the design and implementation of a DPP system remains to be determined by delegated acts, making it challenging to accurately evaluate the potential impact. Firstly, the scope of products covered[39], and the depth of the required traceability is still undefined. For example, in order to properly estimate the carbon footprint of an item purchased in a supermarket, its full history needs to be known – two identical packages of cheese produced in a plant in the Netherlands will have a different carbon footprint if one was transported by an electric lorry to a nearby shop, and the other is transported to Estonia using a truck with a combustion engine. The furthest reaching and most comprehensive version of a Digital Product Passport would therefore require identification at the unit level, containing information not only from manufacturers and dealers, but also logistic companies, retailers, and many other economic operators across the entire value chain of the product – from the manufacturer and their suppliers to the consumer and beyond. Secondly, the degree of detail specified in the regulators' design of a Digital Product Passport also remains undefined, raising questions about the difficulties of achieving smooth interoperability. Differing impacts of DPPs can be observed depending on the sector, type of stakeholder, and country (a big retail chain in Scandinavia will have different challenges than a small shop in Eastern Europe). Taking into consideration such differences and analysing them is out of scope for the report, as it is too early to estimate the impact at a company level.

[39] In accordance with Article 1 of the Regulation, the scope purportedly captures all physical goods placed on the market or put into service, including components and intermediate goods, with the exclusion of 7 product categories (including food, feed, medicinal products and living plants animals and micro-organisms), however the exclusions may yet be modified. Furthermore, parallel regulations may in future impose DPP obligations on certain products independently of the ESPR.

In order to evaluate the impact of differing DPP implementation models, we have prepared three illustrative scenarios, each of which is assumed to require item-level serialisation.

Article 9 of the proposed ESPR presently states that the DPP shall refer to the product model, batch, or item, as specified in delegated acts pursuant to Article 4. These delegated acts are not yet available, however, and the ESPR itself has not been finalised. This assumption of the need for serialisation has been adopted in this report because, without serialisation, many of the benefits of a DPP might fail to materialise.

However, it should still be noted that identification at the product level alone would allow for significantly lower implementation costs of a DPP. It should also be noted that, for higher-volume product types (packaging, food and beverages), the required level of identification may be sufficient if applied at the batch / lot level (which could provide significant traceability insights without creating massive infrastructure investment demands for in-line printing on very high-speed production lines). While this paper does not address the potential cost savings related to a batch / lot level identification requirement vs. a true serialisation requirement, it is intuitive to expect that the overall investment numbers would be meaningfully lower than the scenarios presented below. In our scenarios, we focus on the degree of standardisation of the DPP, and on the kinds of standards that are used. The scenarios are as follows:

1. **Institutional centrally-managed standards / specifications model:**

   The European Commission / Central Government designs and maintains all necessary components for the DPP: including a unique ID system, data model, all the necessary vocabularies/dictionaries and syntaxes. Such a complex solution would ensure interoperability for the European market but not globally and it would require a major amount of work on the side of the regulators and might be costly to implement and keep updated for market participants. Furthermore, in such a scenario there is a risk that manufacturers will treat provision of their DPP as a necessary chore, a 'cost of doing business' separate from their other operations designed to market their products and engage with their consumers. Another risk associated with this scenario is the potential barrier to international trade that such a centralised system could represent. Although such a scenario is rather unlikely, we use it as a bench-mark to highlight both benefits and costs associated with a system run by a public body.

2. **Competing proprietary standards and systems:**

   The European Commission / Central Government introduces high level principles for what should be contained in the DPP, but leaves scope for the creation of different identification schemes and data models, resulting in the emergence of several competing standards partially overlapping, without a guarantee of interoperability (e.g., without synchronisation across international, regional and national standardisation systems). Compared to Scenario 1, in such a case the costs for the European taxpayer are far smaller, but problems with interoperability and frictions in the market result in higher costs for European consumers due to the resultant significant infrastructure investments that would be needed for economic operators that would be required to read / scan / interpret / use multiple identification and data structures, a situation that would be unavoidable considering the global nature of the supply chains in scope.

3. **Global, open, decentralised standards based model:**

   The European Commission / Central Government proposes a DPP based on well-defined, open, and international standards for product identification and data sharing and on European / National standards for all other aspects of circularity model. Such a system would help by considering the interoperability needs of the global supply chains in scope, and would serve to minimise design and implementation costs while simultaneously avoiding market frictions and barriers to international trade of durable goods.

In the following sections, we will indicate what the three different scenarios could mean in terms of standards development and maintenance costs, required adjustments for manufacturers and retailers, market frictions, consumer empowerment and other potential stakeholder involvement.

We do not look at the cost of the collection and use of data itself in our analysis (assuming that in all three cases it will be the same), but rather focus on what three different approaches to the use of standards for the DPP means to the cost of the collection and use of data about products. It is expected that the European Union will provide financial support for the implementation of regulations, to help businesses to achieve goals related to circularity (as has been done under the Sustainable Products Initiative). Financial aid is expected to provide businesses with support for the adaptation to new requirements relating to the implementation of DPPs. This financial aid will be applicable for all three scenarios of implementation presented below. To capture both the required operational expenses and the necessary investments in a comparable way, a 10-year time frame was used. To streamline analysis, all costs are fixed at 2020 constant prices.

5.1. Standard design and maintenance

The DPP requires a system to generate and maintain unique IDs that function across global supply chains, as well as clear, interoperable data models.

A traceability system and data sharing systems are also in scope but, as stated above, it is too early to include them in this assessment. EU standards are noted as tending to increase productivity in the marketplace and amongst businesses, as was noted during presentation of a preliminary results of study for European Commission on the Functions and Effects of European Standards. However, it has been clearly established that the scope of the products that will require a DPP include products sourced from truly global supply chains; the ESPR proposes placing on importers the responsibilities and obligations of manufacturers (as regarding Article 4).[40]

To illustrate the scale of this challenge, it is worth noting that there are over 2 million manufacturers in the EU, producing trillions of items each year. Further-more, full traceability of all of these items would require unique IDs not only for the items, but also for the locations between which they are moved. To ensure a robust ability to create and maintain the necessary data in a DPP, there would also need to be a standardised mechanism / model for the exchange of data about a myriad of supply chain events (e.g. the movement of goods).

Unique IDs are keys that allow product data access, but for a DPP to fulfil its objectives, a well-designed data model is also required. Not only are the attributes that describe each item required, but rules, dictionaries, and syntaxes must also be developed.

Unique identifiers for physical objects are needed to correctly match specific objects with digital information about their characteristics.

For a DPP to work to its fullest (and most granular) potential, it is necessary to ensure that IDs are unique at the serialised instance level of a product – so no two objects can have the same ID, and every object has only one ID.

In the world of innovation and rapidly changing business environments, such dictionaries will have to be constantly adjusted and updated (for example, in order to accommodate new materials). Such constant development of a data model that meets the needs of changing business requires an ongoing dialogue between providers and users from nearly all the sectors of the economy, and from all around the world.

Standards come in different forms, but their proper development and maintenance is always time-consuming and costly. On an international level, standards are usually developed by associations or established standardisation bodies. These organisations, however, span differing sectors, costs models, specifications, and focal points. A standardisation body will typically develop standards within a defined subject matter. Regarding the DPP, by contrast, a necessity arises to cover a far broader scope of economic activities and product areas. This creates an additional layer of complexity which will inevitably translate into higher development costs.

[40] European Commission, 2022. Proposal for a regulation of the European Parliament and of the Council on ecodesign for sustainable products, amending regulation (EU) 2019/1020 and repealing Directive 200/125/EC. See also:
https://eurovent.eu/?q=articles/eu-study-functions-and-effects-european-standards-gen-116900
https://ec.europa.eu/growth/single-market/european-standards/standardisation-policy/benefits-standards_en

International standards help remove trade barriers, support regulatory convergence at international level and avoid the emergence of protectionist measures.

They can bring European industry and businesses the possibility to establish worldwide partnerships and sell their products or services globally. The use of international standards helps guarantee access to global markets, fosters interoperability of products and enhances international competitiveness.

International aspects of standardisation policy

The European Commission's policy aims to align European standards as much as possible with the international standards adopted by recognised International Standardisation Organisations ISO, IEC and ITU. This process is called primacy of international standardisation, and it means that European standards should be based on International standards[41].

The overlaps in subject matter between standards setting bodies can lead to complications, market fragmentation and a major burden on industry. Cooperative arrangements between the European and international standardisation organisations therefore exist and include:

- the Vienna Agreement between the International Organisation for Standardisation (ISO) and the European Committee for Standardisation (CEN)
- the Dresden Agreements between the International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC).

It is costly to develop and maintain standards. For the users of standards, it can be even more costly if they need to simultaneously comply with multiple, competing standards. It is for this reason that major international standards organisations often partner with each other to avoid the creation of overlapping or competing standards.

GS1 is a global, open standards organisation that goes beyond the pure development, publication and management of standards for identification and data models that serve supply chains. With member organisations in 116 countries around the world[42], GS1's work includes the convening of global industry communities in ongoing dialogue about implementation and use of the system of standards that they maintain on behalf of the industries that they serve, most all of which are highly-relevant to the needs of DPP implementation.

The development and maintenance of standards is a time consuming and never-ending process, making a 10-year perspective (at the least) more appropriate. Development of new product data standards for a European based DPP from the scratch would constitute a duplication of already incurred work and expenses. Based on a review of major international standard setting organisations, it is estimated that, over a 10-year time horizon, costs of development and maintenance of standards may range between EUR 200-400 million.

Such a figure, however, would be a significant underestimate, as it does not account for the decades of investment in securing stakeholder buy-in, developing experience, establishing of communities, securing inputs from numerous stakeholders, and establishing the recognition and familiarity across all businesses worldwide. Such global engagement is what has been foundational to making GS1's barcode ubiquitous with retail trade. The length of time and the unique con-text make any attempts to estimate the scale of those investments un-feasible. However, this does not change the fact that any new organisation seeking to manage a DPP on a global scale will face significant additional costs in building the requisite organisational infrastructure and prominence. Development of standards requires long negotiations to reconcile often conflicting priorities between involved parties, which could mean that the true cost would be multiple times larger.

[41] European Commission, 2011. A strategic vision for European standards: Moving forward to enhance and accelerate the sustainable growth of the European economy by 2020. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0311&from=RO
[42] https://www.gs1.org/sustainability

Developing a standard data model is not enough – for a DPP to work smoothly it is essential that all IDs are globally-unique and, by design, fully interoperable.

Although the assignment of identity might seem a straightforward task, one must remember that this process will happen in hundreds of thousands of companies simultaneously, producing millions of items every minute, all around the world. There are many different registers in the EU currently ensuring uniqueness of different ID numbers – from personal ID numbers, through car registration numbers, to company registers. Their functionality varies, but ensuring uniqueness of IDs is always crucial and a costly part of their operations.

A significant part of GS1 in Europe's annual budget is devoted to coherent standards implementation through industry recommendations across the region. Developing (or redeveloping) all the necessary product data standards from scratch to implement the DPP and creating and maintaining a system of unique IDs would constitute a vast and unnecessary cost.

In Scenario 1, where such a new system is prepared and maintained by the European Commission / Central Government, the cost for European taxpayers would exceed EUR 2-3 billion over 10 years, assuming that it would be as efficient as (the already established) GS1 system. In Scenario 2, such costs would not be explicitly visible, as they would be covered by the fees to providers of competing standards. Duplication of work, however, would likely mean that this implicit cost would still be higher than EUR 2-3 billion, especially as economic operators would be required to interact with multiple, different standards. Rather than being borne by taxpayers, these costs would most likely be passed onto EU consumers. In Scenario 3, incremental costs are minor as the DPP would be based on already existing standards and digital infrastructure and any actual standardisation costs would largely be borne by the global industry members that already fund GS1 as a not-for-profit, global standardisation body. The lower cost of Scenario 3 is also in large part due to previously accumulated know-how.

5.2. Impact on competition

Implementing the product passport based on an open standard may boost competition and productivity in comparison to a system of proprietary standards.

Compared to competing proprietary standards, a single, open standards system enables interoperability and reduces the transaction costs of switching between different product suppliers and distributors.

In an empirical context, such results were identified in the case of health insurance[44], auto insurance[45], electricity providers[46], and the mobile phone market[47].

The transaction costs of switching between suppliers and distributors limit market competition by making adjustments more costly.

There is an analogy on the consumer level, where individuals were once unable to switch mobile operators without losing their old phone numbers. Such transaction costs of switching increase the bargaining power of providers and therefore can lead to higher prices, lower product and service quality, and finally lower customer welfare[43].

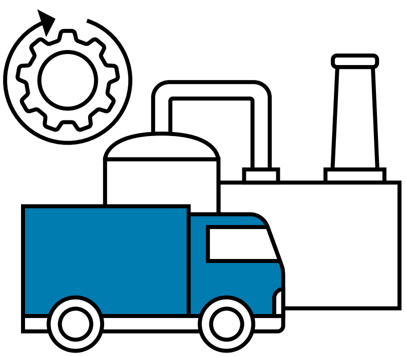
[43] Wilson, Chris M. "Market frictions: A unified model of search costs and switching costs." European Economic Review 56.6 (2012): 1070-1086
[44] Polyakova, Maria. "Regulation of insurance with adverse selection and switching costs: Evidence from Medicare Part D." American Economic Journal: Applied Economics 8.3 (2016): 165-95.
[45] Honka, Elisabeth. "Quantifying search and switching costs in the US auto insurance industry." The RAND Journal of Economics 45.4 (2014): 847-884.
[46] Shin, Kong Joo, and Shunsuke Managi. "Liberalization of a retail electricity market: Consumer satisfaction and household switching behavior in Japan." Energy Policy 110 (2017): 675-685.
[47] Cho, Daegon, Pedro Ferreira, and Rahul Telang. "The impact of mobile number portability on price, competition and consumer welfare." Competition and Consumer Welfare (2016).

Box 2: Mobile number portability regulation and cost reduction

At the turn of the 20th and 21st centuries, many countries implemented regulations requiring mobile number portability, to lower the switching costs on the mobile market[48]. Exploiting variation driven by these policy changes, many researchers have examined the impact of reducing the switching cost on the prices in the mobile market.

Sean Lyons[49], using time series data for OECD countries between 1999 and 2006, estimates that mobile number portability leads to the fall in real average prices of around 8-9% in the short term and 12-15% decrease in the long term. In the European context, Cho Deagon and coauthors obtained similar results[50], with mobile number portability implementation decreasing price by 4-8%, depending on the model specification. Tokio Otsuka and Hitoshi Mitomo[51] show results with a similar order of magnitude in Japan, namely 7-9% cost reduction in two years after policy implementation. Shi and Rhee[52], meanwhile, imply even higher estimates in case of Hong Kong (60% cost reduction in the periods following policy change).

Source	Area	Associated cost reduction
Lyons (2010)	OECD	8-15%
Cho et. Al (2016)	15UE	4-8%
Otsuka and Mitomo (2013)	Japan	7-9%
Shi and Rhee (2006)	Hong Kong	60%



As long as productivity gains are smaller than adjustment costs, suppliers will remain locked-in. In line with this argumentation, Simcoe and Basker show[53] a correlation between the adoption of Universal Product Codes (the US equivalent of an EAN, all of which are GS1 GTINs) and international trade flows. Products in manufacturing industries with larger increases in the adoption of domestic UPCs saw notably faster growth for US imports. This may indicate that supply chain automation reduces retailers' cost of working with foreign suppliers. Since the UPC is part of the globally-interoperable, standard system of GS1 IDs, contemplating the impact on exports is reasonable. In fact, the study found statistically insignificant results for exports, with near zero estimates of impact. Moreover, the UPCs implementation had a positive impact on employment[54] and labour productivity[55].

We estimate that productivity reductions due to lower competition in the case of a proprietary-based DPP (Scenario 2) could lead to up to EUR 71 billion losses compared to a scenario with a well-defined standard (Scenarios 1 and 3). The effects of market-based and centrally managed solutions should be similar in this domain, as both reduce friction between market participants.

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[48] Maicas, Juan Pablo, Yolanda Polo, and F. Javier Sese. "Reducing the level of switching costs in mobile communications: The case of mobile number portability." Telecommunications Policy 33.9 (2009): 544-554.
[49] Lyons, Sean. "Measuring the effects of mobile number portability on service prices." Journal of Telecommunications Management 2.4 (2010).
[50] Cho, Daegon, Pedro Ferreira, and Rahul Telang. "The impact of mobile number portability on price, competition and consumer welfare." Competition and Consumer Welfare (2016).
[51] Otsuka, T., & Mitomo, H. (2013). User benefits and operator costs of mobile number portability in Japan and impact on market competitiveness. Telecommunications Policy, 37(4-5), 345–356. doi:10.1016/j.telpol.2012.04.008
[52] Shi, M., Chiang, J., & Rhee, B. D. (2006). Price competition with reduced consumer switching costs: The case of "wireless number portability" in the cellular phone industry. Management Science, 52(1), 27–38
[53] Basker, Emek, and Timothy Simcoe. "Upstream, Downstream: Diffusion and Impacts of the Universal Product Code." Journal of Political Economy 129.4 (2021): 1252-1286.
[54] Ibid.
[55] Basker, Emek. "Raising the barcode scanner: Technology and productivity in the retail sector." American Economic Journal: Applied Economics 4.3 (2012): 1-27.

5.3. Barriers to trade

The implementation of the DPP has the potential to shape barriers to trade.

Imports from outside the EU would need to comply with DPP data standards to provide EU supply chain intermediaries or endpoint sellers with the necessary information as required by anticipated regulation. This would constitute a need for non-EU businesses to accommodate and adopt the DPP-relevant data systems and standards. The nature of this transition will pose costs for non-EU businesses, just as they would within the EU.

However, these costs may potentially pose a disproportionate threat to their margins.

Were the EU DPP to be based on proprietary standards, the increased adoption costs could prove significant enough to either necessitate significant price adjustments (threatening importers), or re-evaluation of business cases entirely, potentially reducing the general willingness to export to the EU (where other regions may present lower costs through the absence of additional data requirements). These costs would naturally compound further, the greater the number of competing standards which each manufacturer would need to accommodate.

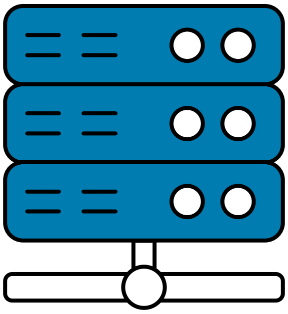
The disparity in data requirements between EU and non-EU businesses could potentially be classified as a technical barrier to trade under the MAST 2012 Non-Tariff Measures (NTM) classification[56]. As Cadot et al. note, this barrier presents in the form of "regulatory distance" – created by differences in regulatory expectations imposed on products between countries. In other words, the EU would effectively be imposing a NTM on a non-EU supplier, which that supplier would not face in trade elsewhere. Technical barriers to trade should be given special consideration, as the authors note these present the most significant impacts, through consistently higher ad valorem equivalent estimates on unit value, when compared with Sanitary and Phytosanitary measures or Border Control measures, for example.[57]

GS1, however, provides an international, open standards system with which all businesses around the world are already well-acquainted – with most non-EU businesses exporting to the EU already utilising the Global Trade Item Number (GTIN) in the form of barcodes. Building a DPP data standard on the backbone of GS1 standards would therefore reduce the adaptation burden on foreign businesses who are already using GS1's standards, data models and system of identity. This option could additionally mitigate the risks of non-trade barriers the DPP might present, risks which would be compounded under a scenario where manufacturers would be expected to accommodate competing standards if they sought to freely access the entire EU market (and face no restrictions based on retailer choices regarding standards).

[56] Cadot, O., J. Gourdon and F. van Tongeren (2018), "Estimating Ad Valorem Equivalents of Non-Tariff Measures: Combining Price-Based and Quantity-Based Approaches", OECD Trade Policy Papers, No. 215, OECD Publishing, Paris.
[57] Ibid.

5.4. Data integration

The implementation of the DPP may also require additional expense regarding data integration, depending on the implementation scenario.



Various entities will require access to integrated data so as to enable comprehensive market analysis, policy evaluation, or product management. This will include, but is not limited to, regulators/supervisory bodies, recyclers, repair and maintenance businesses, second-hand stores, and analysts. These entities are important, and cannot be overlooked, as their contribution will be crucial for the shift from a linear to a circular economy. Such entities working towards circularity will require the ability to obtain a comprehensive market view, as well as manage products and information across all standards. This may be particularly burdensome where similar or even identical products on a market are fragmented by the standards utilised for their DPPs. Under Scenario 2, in which multiple data standards are allowed to compete, entities needing to interface with DPPs to extract information, whether as part of business operation (as in the case of recyclers or repair shops), or analysis / data collection (as in the case of supervisory bodies), will need to develop or acquire the capabilities to aggregate, integrate, or consolidate all products regardless of the standard used. This will inevitably be associated with further costs which, depending on the entity, will likely be passed onto either taxpayers or consumers, and could erode the gains sought by the DPP ab initio. An example of such costs could be found in tobacco market.

The European Union has recently adopted legislation to fight illicit trade by requesting traceability as an obligatory feature in this area.

As the identification standards for track and trace systems differ between EU countries, the European Commission needed a system to integrate data in one place. Even in this relatively simple case (of just one type of product, with a simple ingredient list, in a highly regulated and concentrated market) an external service provider was needed. Judging by the sheer volume of items, the task in the case of wider DPP would be at least 200 times greater. Taking into account the variety of products would make it far more complicated. As at the moment it is hard to find similar operating systems; expert opinions on aggregate costs were very cautious, but estimates in the hundreds of millions (EUR) were deemed plausible.

Furthermore, in the tobacco legislation, the implementations were by country and data aggregation only occurred at the EU level. Under the ESPR, however, data aggregation must happen at many levels, which under a scenario of competing proprietary standards could exponentially complicate implementation and raise costs even higher. A multiplication of standards will necessarily duplicate downstream costs, as re-tailers may need to adjust systems to operate with multiple standards. It may be that in some cases it will be the manufacturers needing to adjust to the needs of differing retailers; the precise outcomes will depend on the differing bargaining powers, but costs will be duplicated nevertheless.

5.5. Implementation costs for manufacturers and retailers

Experts contacted during the preparation of the report agreed that the majority of the implementation costs will most probably fall on the producers.

The magnitude of the costs depends largely on the shape of the adopted standards and their method of implementation. Deployment of a DPP based on well-defined, open standards (ISO, GS1) would be the most cost-effective solution, especially in the long term.

Firstly, expert analysis of one of the world's largest soft drink manufacturers showed that a serialisation system based on an open GS1 standard (Scenario 3) leads to lower costs compared to cooperation with a solution provider using a proprietary system (Scenario 2). In this particular case, the proprietary system would cost around EUR 6 per 10,000 units produced annually. A similar figure was also given in the EU Impact assessment on technical standards for the establishment and operation of a traceability system for tobacco products, where the implicit cost was in the range of EUR 5.6 per 10,000 products for generating unique IDs, and a further EUR 8.9 for labelling. Plausible costs for the manufacturer therefore fall in the range of EUR 6 - 14 per 10,000 units annually. On the other hand, the implementation of a SGTIN (serialised GTIN) would require an initial capital outlay of EUR 8 per 10,000 produced units, but this cost would definitely fall over time – after the lifespan of the initial machines, it is expected that their replacement costs will be lower than their initial purchase costs. Leveraging a single, open, global standards system (like GS1), labelling providers would compete to provide their services, unlike in the case of proprietary standards. Assuming that competition between service providers drives the price down by up to 20%, the Scenario 3 cost would fall to EUR 6.4 per 10,000 units. Taking into account a 5-year lifespan of a labelling machine (al.-though it might be longer for particular types), this means that over a 10-year period in Scenario 3, the cost would be between EUR 14-15 for 10,000 units, compared to EUR 60 -140 for 10,000 units in Scenario 2. It should be noted, however, that the true difference in costs might be even bigger.

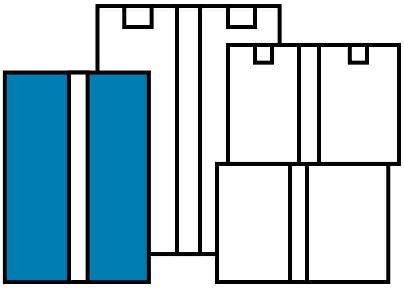
Although in Scenario 2 the service provider will cover IT costs, there still might be significant management costs. One factory supplying 3 different retailers using different identification standards will be harder to manage than a scenario where one identification standard is shared by these retailers. Put simply, it should be expected that the use of multiple, competing standards across the global supply chains will have a multiplicative effect on overall costs, as producers will be required to support multiple systems that may or may not be capable of interoperating or using the same equipment in production.

Even if the service provider covers the costs of labelling for each production line, it will still make resource management harder and more prone to errors. In addition to the costs of managing multiple data standards, producers will also face additional costs related to the individual management and separate tracking of different resource streams. The impacts of this are, however, challenging to quantify as the present systems for managing and tracking resources in production are often opaque.

Scenario 1 would fall somewhere in between – although the standard would be handled by the European Commission, reducing the power of service providers (bringing costs lower than in Scenario 2). On the other hand, implementation of a standard developed by businesses like GS1 is usually cheaper, as the standard is viable only when it proves cost-efficient for willing market participants.

A public administration developing standards does so by requiring business to adopt it, which weakens the incentives to look for the most cost-effective solutions. One example of such a solution could be the Russian Mandatory Traceability System, where costs for manufacturers are much higher – around EUR 70 per 10,000 units (Taking the above into account, in Scenario 1 we assume that implementation costs would be somewhere between EUR 14.4 and EUR 30 per 10,000 units. However, if other countries adopt similar traceability systems, then interoperability becomes all the more difficult (if not impossible) to achieve.

The overall costs of implementation depend on the price of ID per unit of product, and the number of products. According to our estimates, approximately 5 trillion items (2.8-7.6) are placed on the European market in the sectors covered by this study each year. This could feasibly be a volume covered by DPPs. This includes 4 trillion items of packaging (2-5.9), 1.1 trillion items of food and beverages (0.8-1.6), 21 billion items of textiles (17-25.5), 1.1 billion items of consumer electronics and household appliances (0.9-1.3), and 1 billion items of batteries (0.7-1.3). Such large numbers of items necessarily translate into high aggregate costs, even when an additional im-posed cost per item is very low. For simplicity, looking only at a central estimate yields the following costs for manufacturers in our scenarios over a 10-year period:



1. **Institutional centrally-managed standards / specifications model:**

   Between EUR 9 billion and EUR 18 billion

2. **Competing proprietary standards and systems:**

   Between EUR 63 billion and EUR 152 billion

3. **Global, open, decentralised standards based model:**

   Between EUR 3 billion and EUR 7.1 billion

The lower-end costs related to the implementation of a DPP based on standards result from the open and global nature of the standards used. This creates a framework where technology providers can compete, developing efficient and interoperable solutions that are based on those open standards. The differences in the above estimates result from the differing nature of the potential standards (open or proprietary). Proprietary standard models may involve fees based on production volume, increasing the financial burden on businesses. Furthermore, a training infrastructure is an important asset of open standardisation bodies, while proprietary standards and models of implementation will likely require additional investments in building multiple and different training regimes.

Such costs, however, could be cut by even as much as 80% if packaging is excluded. Also, limiting identification requirements to a product level (not batch, lot or class level) would further allow for radical cost reduction. As mentioned above, raising the level of necessary identification up to the batch or lot level (instead of the serialised level) could have meaningful impacts on the costs, especially for packaging and for food and beverages.

Scenarios 1 or 3 would cause far less disruption to retailers than Scenario 2, in large part due to the avoidance of cost duplications resulting from managing multiple standards to perform the same task. In Scenario 2 (which is the costliest of the three), adaptation costs will be included in the fees charged by providers of proprietary solutions. Nevertheless, retailers will face additional costs as a result of traceability requirements. At this moment, however, it is not known to what extent point-of-sale (POS) will need to be recorded – this will likely differ from sector to sector. However, rebuilding POS would be easier and cheaper in the case of one identification standard.

Table 4. Estimated number of products with the requirement of ID placed on the EU market (billions annually per 445 m EU inhabitants)

	Lower estimate	Central estimate	Upper estimate
Packaging	1980	3960	5940
Food and beverages	841	1114	1626
Textiles	17	21	25
Consumer electronics and household appliances	0.9	1.1	1.3
Batteries	0.7	1.0	1.3
Total	**2839**	**5098**	**7595**

5.6. Market creation and consumer empowerment potential

Uptake in scanning and automated inventory management enables retailers to handle wider assortments of goods.

This has been shown to translate into manufacturers producing and providing a greater variety of products, as the burdens of this variety (on retailers) are increasingly mitigated[58]. Consequently, the need of the consumers can be better served on the market, leading to an increase in consumer demand and welfare.

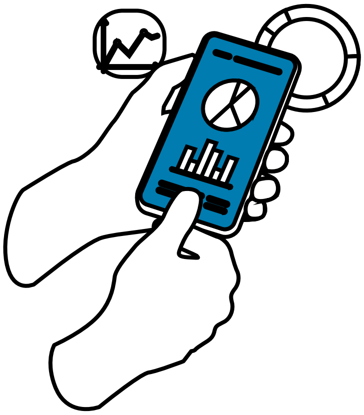
Basker and Simcoe show that, as the UPC (GTIN) diffused through retail channels in the early 1980s, the grocery sector saw a sharp uptake in products stocked, as well as the introduction of new products.[59] Furthermore, UPC (GTIN) uptake appeared to have a similar impact on the registrations of new trademarks by grocery manufacturers, which similarly accelerated. By analysing Census microdata in tandem with data from the US Patent and Trademark Office, it was found that obtaining a UPC significantly increased the annual propensity of manufacturing firms to register new trademarks.[60]

Another stream of literature suggests that standards help address asymmetric information between buyers and suppliers with goods of heterogeneous quality[61]. Standards provide consumers with greater ranges of information regarding their products. This increased access to information

[58] Basker, E. and Simcoe, T., 2021. Upstream, Downstream: Diffusion and Impacts of the Universal Product Code. Journal of Political Economy, 129(4), pp.1252-1286.
[59] Ibid.
[60] Ibid.
[61] See Cadot et. all

and data could, from the perspective of consumers, increase the attractiveness of certain items – increasing their willingness to pay, or their demand for goods – perhaps as a result of greater comfort and under-standing of the goods' provenance, applicable certifications, and easy access to information on maintenance, repairability, or sustainability performance. Consumers pay attention to how goods are manufactured and declare a willingness to pay more for eco-friendly goods[62]. The introduction of a DPP standard, by making this information readily available, should lead to consumer empowerment.

However, for information to be effective, it must be easily obtained and accessible. A well-defined open standard based DPP (market-based or centrally-planned) would reduce the scope of unnecessary frictions related to the translation of this information to a consumer-friendly form.



Box 3: Market size and prices for different forms of DPP implementation

To understand how the standardisation of the product passport will affect the market equilibrium prices and quantities in each scenario, we need to analyse its impact on supply and demand.

The shift in supply will be proportional to the cost of adaptation to a new standard. According to our estimates, it will be the lowest in the case of the market-based open standard approach (Scenario 3). When it comes to comparing centrally-planned standards (Scenario 1) with the market-based proprietary solution (Scenario 2), two effects fight each other. On the one hand, the centrally-planned solution leads to higher fixed costs than proprietary system lined with standard design and maintenance. On the other hand, deeper standardisation in this scenario boosts competition among suppliers more than in proprietary system that leads to lock-ins. The second effect is likely more dominating, implying a centrally planned open standard solution could be moderately more effective.

At least two components affect the demand curve: an increase in the product variety and a decrease in information asymmetry. The increase in product variety is proportional to the reduction of the burden related to cooperation with many suppliers. The higher the degree of standardisation, the lower the cost of switching suppliers and the higher the potential for inventory management automatisation. Therefore, that channel will be more robust for the centrally planned and market-based open standards, due to their higher integration compared with market-based proprietary standards. The second effect linked to the reduction of asymmetric information will similarly generate a higher impact for the centrally planned and market-based open standards. Therefore, the potential for market creation and demand increase is the highest in these two cases.

Combining the effects on supply and demand, we can assess the impact on market equilibrium. Point X corresponds to the prices and quantities in the scenario without standardisation of product passports. Therefore, no additional cost has to be covered, but there is no potential for standardisation driven market creation as well.

Point A corresponds to Scenario 2 with market-based proprietary standards. The cost of the policy implementation leads to higher prices — the benefits for the consumer are relatively small. Therefore, the quantity of the goods traded on the market may even decrease at the equilibrium.

Point B corresponds to Scenario 3 – the equilibrium with a market-based open standard. The increase in cost is lower compared to the proprietary solution, and market creation is higher. For this reason, the quantity at the equilibrium is most likely to increase.

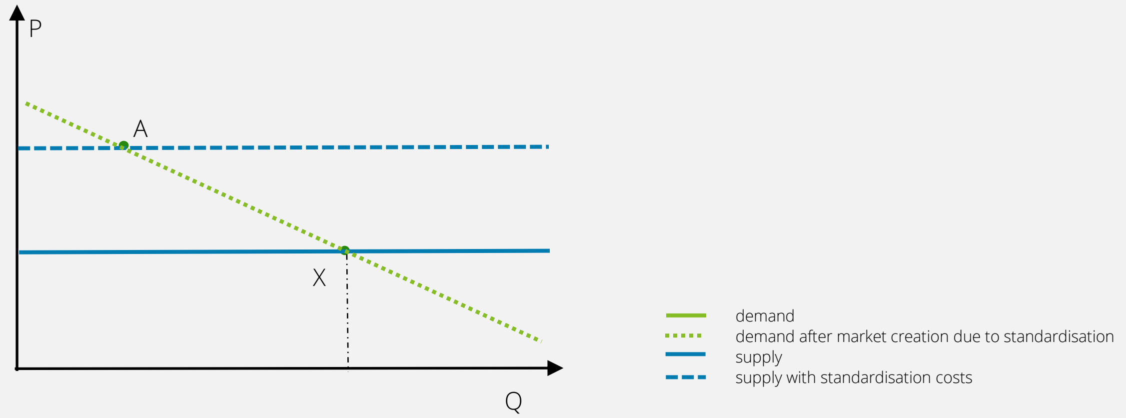
Point C corresponds to Scenario 1 – the equilibrium with the centrally planned standard. While the market creation potential is similar to the market-based open standard-based DPP, the cost of implementing such a solution is higher. Therefore, the quantity in this scenario will take intermediate values.

[62] Eight of ten Poles are concerned about the climate changes (deloitte.com)

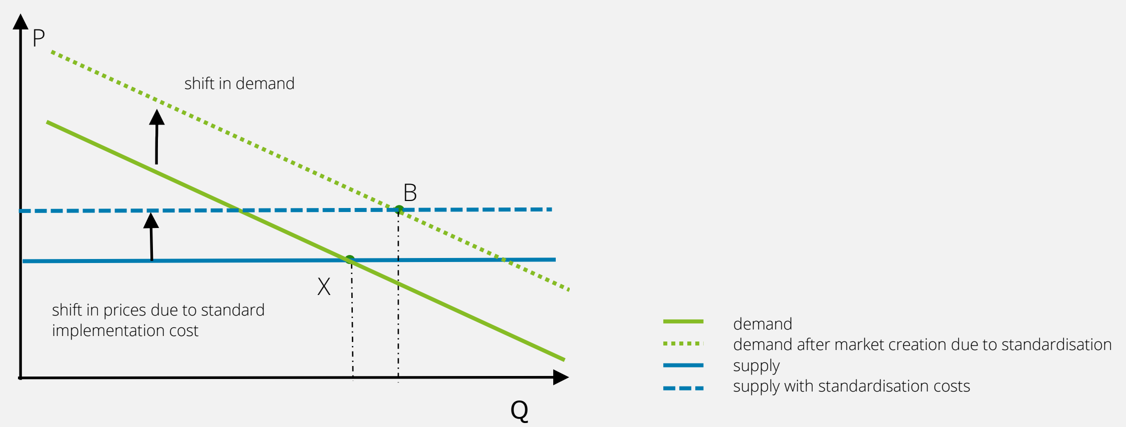
Box 3 (continued): Market size and prices for different forms of DPP implementation

Figure 9. Effects of product passport standardisation on market equilibrium under three alternative scenarios

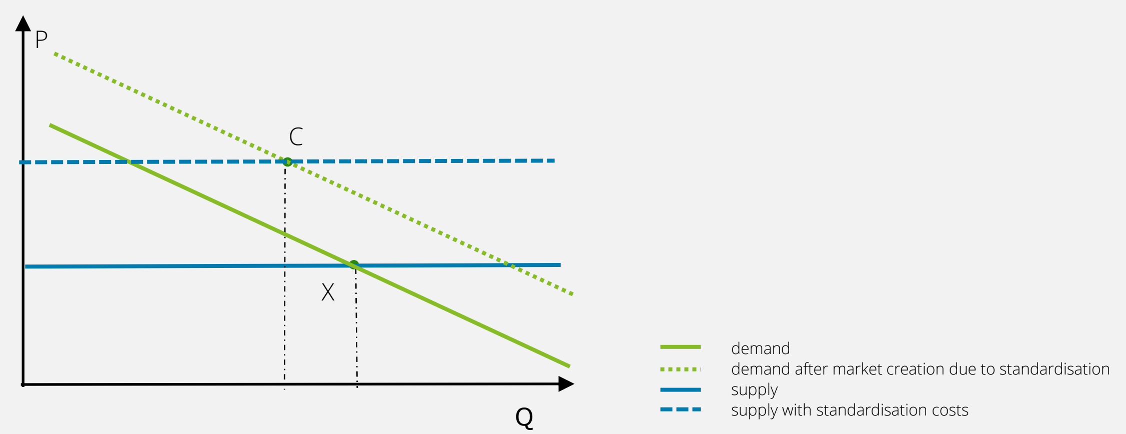
(a) Competing proprietary standards and systems (Scenario 2)



(b) Global, open, decentralised standards based model (Scenario 3)



(c) Institutional centrally-managed standards / specifications model (Scenario 1)



5.7 Overall impact

The Digital Product Passport will empower consumers and will act as an enabler for a circular economy, but the net benefit will heavily depend on the implementation costs.

As some important requirements are still unknown (and will remain so until the EU produces acts covering different sectors), calculations in this report depend strongly on a number of assumptions built into scenario models. In order to illustrate the potential scale of the costs, we assumed full serialisation of items placed on the European Market. From the three scenarios analysed, the costs would be by far the biggest in the case of competing standards (Scenario 2). Besides significant costs for manufacturers, transaction costs in the economy would go up, distorting competition. Unleashing the potential of data from a DPP would also require additional outlays.

These factors would create costs in the range of EUR 63 billion to EUR 152 billion over the next 10 years. Compared to EU GDP, this figure might not seem that impressive (around 0.1% GDP annually), but the scale of this figure should not be underestimated, being roughly equal to the GDP of Malta, total German government expenditure on cultural services, or all EU-aggregate government expenditure on biodiversity and landscape protection. Broadly speaking, therefore, the whole value created in Malta annually would be needed to cover the costs arising from the introduction of a DPP in EU.

Such expenses, however, are not necessarily required in every scenario; building the DPP on well-defined standards like GS1 and ISO (Scenario 3) could lower those costs to a range of EUR 3 billion to EUR 7.1 billion, freeing up resources for other goals. The last option – to develop the required standards at an EU level (Scenario 1) would be costly for taxpayers, would take significant ongoing investment for maintenance, but would also reduce transaction costs in the economy. Overall costs (EUR 9-18 billion) would nevertheless remain significantly higher than in the case of using already existing standards.

It should be also stated that the presented scenarios are theoretical for the purposes of providing an impact analysis.

The final method of DPP implementation will only be known after publication of relevant pieces of legislation and the market response.

This might result in a mixture of scenarios, for example if the assumptions made for Scenario 2 and 3 were to overlap or merge.

Using open and global standards as a foundation of the EU system is essential to enable the free movement of goods globally, to minimise disruption along global supply chain networks and to ensure data interoperability.

The capability of accessing a plethora of information pertaining to items, allowing for the identification of entities, locations, logistics, certificates, product composition, raw materials and CO_2 emissions, constitutes a watershed moment for supply chains and for sustainability. Such data, organised and accessible through a DPP, unlocks product traceability and enables increased transparency along supply chains. It empowers consumers, increases effectiveness and efficiency for companies, supports public policies related to product safety and anti-counterfeiting, and ultimately serves to enable and incentivise a circular economy.

6

Appendix

Number of items

Items have been aggregated in the following manner:

Consumer electronic and household appliances do not include any other items beyond those sub-categories. Apparel and footwear contain apparel and footwear only. Food and beverage includes alcoholic drinks, food, hot drinks, and non-alcoholic drinks, in line with the categorisation provided by Statista.[1]

All numbers from Statista reports are estimates for 2022. Batteries adopt European Commission[2] categorisation of automotive, consumer, and industrial. European Commission numbers are an approximation of a typical year.

Packaging refers to the total volume of packaging per Eurostat data for 2019.[3]

Precise estimates of the number of items are given for apparel, consumer electronics, footwear, and household appliances, while for others assumptions had to be made on a per kilogram, and per litre basis. Assumptions were as follows:

- For alcoholic drinks a 0.5-liter item (a typical beer bottle) with a range of 1.5-2.5-liter,
- For batteries (automotive) a 15 kg item (a typical car battery) with a range of 12-17 kg range,
- For batteries (consumer) a 0.17 kg item with a range of 0.13-0.25 kg (a typical 4-pack of AA batteries weighs 0.13 kg, but very large packages are also popular),
- For batteries (industrial) a 250 kg item (a typical electric vehicle battery) with a range of 200-300 kg,
- For food a 0.25 kg item with a 0.17-0.33 kg range,
- For hot drinks a 0.2 kg item (a typical tea package is 0.1 kg, but coffee has much larger packages and is much more popular) with a 0.13-0.25 kg range,
- For non-alcoholic drinks a 1-liter item (compromise between small 0.33 and 0.5 bottles, and larger bottles of 1.5-2-liters) with a 0.8-1.2-liter range, and
- For packaging a 0.02 kg item (half the weight of a large plastic bottle) with a 0.01-0.04 kg range (between a large plastic bottle and a 0.33 aluminium can of 0.015 kg).

[1] Statista (2021), Household appliances report 2020, Statista Consumer Market Outlook – Market Report, https://www.statista.com/outlook/cmo/household-appliances/europe; Statista (2022), Non-Alcoholic Drinks report 2022, Statista Consumer Market Outlook – Market Report, https://www.statista.com/outlook/cmo/non-alcoholic-drinks/europe; Statista (2020), Alcoholic drinks report 2021, Statista Consumer Market Outlook - Market Report, https://www.statista.com/outlook/cmo/alcoholic-drinks/europe; Statista (2021), Food report 2021, Statista Consumer Market Outlook, https://www.statista.com/outlook/cmo/food/europe; Statista (2021), Apparel market report 2021, Statista Consumer Market Outlook, https://www.statista.com/outlook/cmo/apparel/europe; Statista (2022), Footwear report 2022, https://www.statista.com/outlook/cmo/footwear/europe; Statista (2021), Consumer electronics report 2021, Statista Consumer Market Outlook – Market Report, https://www.statista.com/outlook/cmo/consumer-electronics/europe; Statista (2022), Hot drinks report 2022, Statista Consumer Market Outlook – Market Report, https://www.statista.com/outlook/cmo/hot-drinks/europe
[2] DG Environment (2021), Batteries and accumulators, European Commission
[3] Eurostat (2022), Packaging waste by waste management operations

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