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Payments to grow your world

Corporate Social Responsibility

Accelerating the decarbonisation of payments.

Towards 1g CO_2 per transaction: recommendations based on life cycle assessments.

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Preamble.

Worldline's CSR department asked me to conduct an external analysis of the carbon footprint associated with payment methods, using the original life cycle assessments (LCAs) they had commissioned. The goal was to compare the environmental impacts of different transaction methods.

This document presents observations that I believe to be useful after conducting a detailed analysis of these LCAs. The aim is to place Worldline's contribution in the context of the rapid transformation of payment systems, characterised by a profusion of digital innovations.

Additionally I will focus on how these LCAs enrich the "state of the art" and are likely to lead to recommendations, both in terms of coordination within the payments ecosystem, and of public regulation aiming to accelerate the necessary developments in the field of decarbonisation of payments.

These comments are also an opportunity to shed light on how players in payment systems, in addition to meeting the decarbonisation goals within their own operations, can also actively contribute to improving the environmental performance of their industrial partners and end consumers.

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Executive summary.

The purpose of this document is to provide a comprehensive analysis of the decarbonisation of payment systems, considering their rapid digitisation (1) and evaluating the scope of the original life cycle assessments (LCA) commissioned by Worldline (2). This analysis leads to a discussion on the objective of organising payment transactions to achieve 1g of CO_2 equivalent per unit (3) and concludes with the “next steps for moving forward” (4).

1) Payment systems in a dual transition: digital and environmental.

- The digital payments sector is evolving rapidly: although cash still dominates in terms of the number of transactions and monetary volumes, its use is gradually declining. The rise of the Internet and new technologies is contributing to the rapid adoption of digital payments. Furthermore, the Covid-19 pandemic has accelerated favouring electronic payments for purchases and financial transactions.
- The environmental footprint of payment circuits includes both visible elements, such as plastic bankcards and payment terminals, and invisible components, including telecommunications networks and data centres. To assess this footprint, it is necessary to take into account the diversity of payment solutions enabled by digital technologies and to study a range of solutions, rather than being limited to cash payment circuits.

2) Scope and added value of the life cycle assessments initiated by Worldline.

- In this context, Worldline has commissioned two original life cycle assessments (LCAs), in Belgium, with the following objectives: firstly, compare the environmental footprint of an in-store bankcard transaction with its online equivalent; and, secondly, to compare the results obtained with a cash transaction.
- For in-store transactions, the footprint was 2.45g CO_2e, mainly due to ticket printing (42%), the payment card (34%) and the payment terminal (20%). In the e-commerce scenario, the footprint of online transactions was 11.9g CO_2e, due to the Belgian authentication device being the main contributor (75%), followed by the smartphone (15%) and the card (7%).
- The second study showed that the environmental impact of a cash payment based on an ATM withdrawal is 19.5g CO_2eq. Most of this impact (80%) is due to the cash dispenser. Since in Belgium, an average of seven payments are done with one withdrawal, this brings the average cash payment transaction to 2.8 gCO2eq. Consequently, the environmental impact of cash payments is linked to the number of transactions carried out with a single cash withdrawal. To compare cash to electronic payment transactions on the same basis, the environmental cost generated by the mobility to get the cash at the ATM must be considered, adding then 34g CO_2eq to the 2.8g CO_2eq of the transaction.
- These LCAs provide added value by allowing payment methods to be ranked according to their carbon footprint and conditions of use. Identifying threshold effects, which modify the payment footprint hierarchy on either side of them, is a valuable contribution to understanding the environmental impact of payment methods.

3) Targeting payments of 1g CO_2: nature of the objective and potential levers to be activated.

- The LCAs commissioned by Worldline identify the possibilities of achieving transactions at 1g CO_2eq per unit for different payment methods. With the exception of cash payments, this objective appears feasible for the other payment methods assessed, provided, in particular, that the printing of tickets is eliminated in the short term, and, in the longer term, that the provision of a bankcard is made optional (using a smartphone for the same functions). To get an idea of what is at stake, consider that the switch from 2.45g to 1g for digital transactions managed by Worldline in Belgium would prevent the emission of 2,100 tonnes of CO_2 per year.
- But, the debate on the environmental effects of digital technology is complex and goes beyond simply measuring the direct carbon footprint. It is also about examining how these technologies can transform socio-economic organisations, and how payment services can play a role in promoting environmentally-friendly consumer behaviour. For example, they can incorporate features such as reward systems for eco-responsible purchases and provide information on the carbon footprint of purchases. In addition, many blockchain projects (using cryptocurrencies) are aligned with sustainable development goals, aiming to decentralise carbon markets and the financing of environmental projects such as agroecology and reforestation, among many ongoing experiments.

4) Next steps for moving forward.

- These LCAs have first highlighted the considerably higher footprint of a cash transaction payment compared to an electronic transaction.
- Focusing on electronic payment transactions, this study illustrates the additional possibilities for optimising digital payments.
- These different optimising solutions are as follows:
  - **Banks need to extend the life of cards and terminals** and include them in a circular economy approach at the end of their life; In addition, the trust they have established with their customers can give them an advantage in their ability to inform them about the footprint of their payments, and about good practices in this area. More specifically **Belgian banks need to stop using an authentication device** to authenticate cardholder in an eCommerce transaction. Looking further ahead, banks should be moving away from cards and payment terminals;
  - **Merchants need to convince customers to dispense with tickets;** as things currently stand, the former have no specific interest in it, which is problematic, and this ticket impression weighs heavily on the overall footprint of the process. It is essential that public policy gradually restricts the use of tickets; **Belgian merchants need to avoid printing the receipt,** since their system is online.
  - **Legal regulator need to make it possible not to print the cardholder and merchant receipts;** it can also influence the merchant not to print the receipts;
  - **Payment providers need to optimise their systems** to ensure the lowest CO_2 footprint;
  - **Terminal manufacturers need to ensure that they optimise their energy consumption** in active and standby modes and do not "outbid" them (the trend towards tablet-type screens is counterproductive in this respect), transaction processors need to store the minimum amount of data, extend the life of IT equipment and dynamically adapt the sise of processing platforms to the volume of transactions;
  - **Consumers must do their bit by agreeing to do without a ticket,** by limiting the number of cash withdrawals without fragmenting them into small samples, ... Such a development will obviously take time, and will require better information on their part, a shared responsibility between the public authorities and the players in the payment ecosystem.

Introduction: why care about the environmental impact of payment systems?

The cash industry as a whole makes extensive use of carbon-emitting resources and other materials that have an impact on the environment: from paper and polymer to metal materials, electricity and gas, transport fuel, plastic and water. But payments are also – and increasingly so, given the dynamics of innovation leading to a profusion of digital payment methods – part of the debate on the environmental footprint of information and communication technologies, a debate that has intensified considerably in recent years: with the Paris Agreement setting the ambition to limit the long-term temperature rise to well below 2°C (above pre-industrial levels), and preferably not exceeding 1,5°C, the horizon for carbon neutrality has moved closer to 2050. Which means we need to keep an eye on the sectors that emit the most. In this context, as the carbon footprint of digital activities is growing (and generally compared to that of air transport), it is logical and desirable that it should be the subject of particular attention.

As we will see below, the payments industry has a number of levers at its disposal to help it adapt to the decarbonisation imperatives: eco-design, energy efficiency, decarbonised energy sourcing, circular economy mechanisms, and so on. In other words, the rapid diversification of electronic means of payment, even if it reduces the use of cash (in proportion to the number of transactions), only marginally reduces the weight of the banknotes and coins distribution circuit, and this overlay of circuits is not, in essence, conducive to decarbonisation objectives. Furthermore, while it is possible to identify good practices, the variety of cultures and needs from one country to another makes it impossible to imagine universal solutions for achieving low-carbon payment transactions.

Echoing these "methodological" difficulties, at this stage, there is no solid regulation specifically defending "green" payments. And, regulations concerning sustainability and eco-responsible practices may differ from country to country. A lack of harmonisation of rules can hamper the coordination and consistent implementation of sustainability initiatives across the payments ecosystem.

The purpose of this document is threefold:

- **To offer a panoramic analysis of the issue of decarbonising payment systems, in the context of its accelerated digitization.** For this purpose, we will focus on the euro zone, while emphasising that the trends identified (decline in cash, development of a profusion of digital payment channels, etc.) correspond to fundamental trends beyond this perimeter. In this first section, we will also highlight some of the results of work on assessing the environmental footprint of means of payment, noting that there are still several gaps, apart from the analysis of the life cycle of banknotes (generally initiated by central banks) (1).
- To assess the scope of the original LCAs commissioned by Worldline, and to position its contributions in comparison with the "state of the art". Knowing that Worldline, to guide its own decarbonisation efforts (as part of its TRUST 2025 plan), has commissioned two original LCAs, to compare the environmental footprint of an in-store bankcard transaction with its online equivalent; and, secondly, to compare the results obtained with a cash transaction.
- **To discuss of the objective of organising payment transactions that do not exceed 1g eqCO_2 equivalent per unit** (3). The conclusions of the LCAs allow us to measure (for cash or card transactions in shop, or online) the gap for reducing the carbon footprint of these transactions, of which the order of magnitude is 2 to 3 g. Closing this gap will not be without its challenges, particularly in terms of coordination within a complex ecosystem. But this effort could have a number of direct and indirect benefits for the community, which we feel important to discuss.

We will conclude by **endeavouring to identify** the **"next steps for moving forward"** (4).

1. Payment systems in a dual transition: digital and environmental.

To analyse the challenges of reducing the environmental footprint of payment systems, it is first important to identify the trends in their development. These are characterised by rapid diversification, driven in particular by digital innovations. However, this development does not mean that cash is disappearing, to which consumers remain attached, even though notes and coins are playing a decreasing role in payment transactions.

Such a development, characterised by the growing importance of digital technology, makes it all the more important to measure the environmental footprint – for carbon in particular – of each payment method. At this stage, however, the analyses available in this area are fairly patchy, focusing largely on the cash circuit.

1.1. On the digital front: gradual erosion of the use of cash and profusion of electronic means of payment.

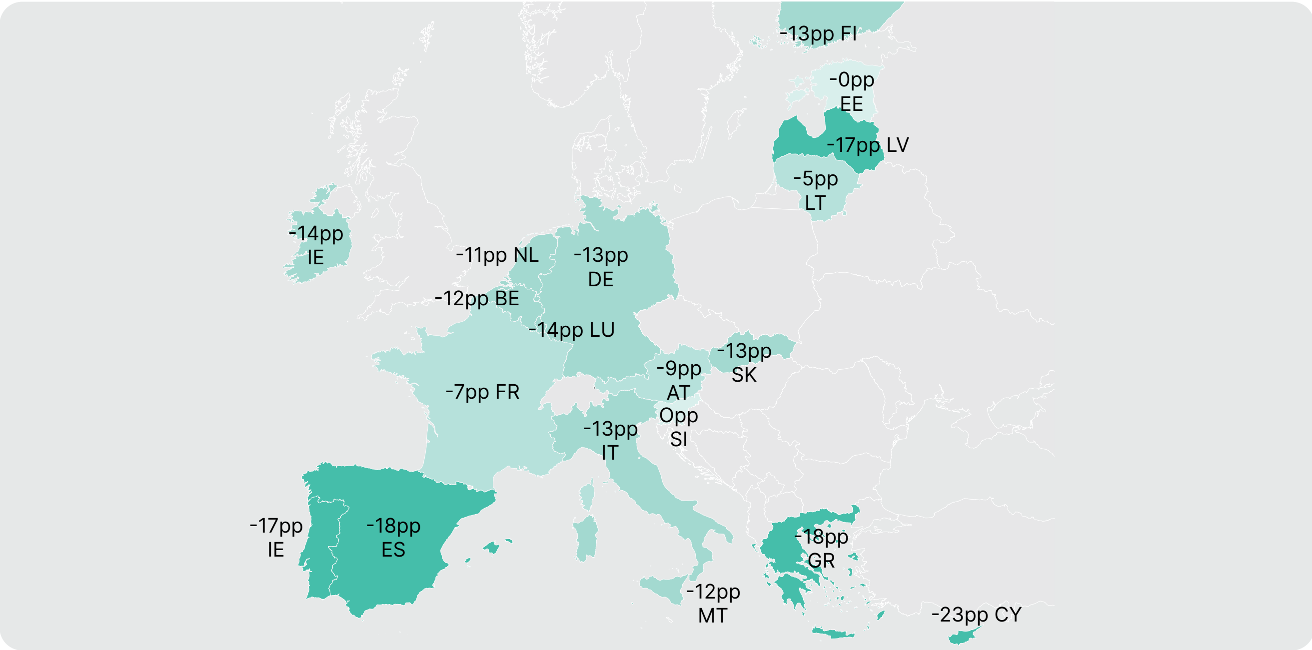
The European Central Bank has carried out a number of studies into consumer payment preferences in the eurozone, the most recent published in 2022 (ECB 2022) being a fairly accurate description of the rapid changes in payment habits.

Although focused on Europe, the trends that emerge from this study reflect a more general trend – albeit with a degree of heterogeneity from country to country – driven in particular by technical progress, and accelerated by the collective experience of COVID-19.

The study conducted by the ECB shows that, while cash is still the predominant means of payment, its importance is declining both in terms of the number of transactions and monetary volumes, and that cash is becoming part of a considerably diversified landscape due to the profusion of innovative electronic payment methods:

- While cash remains the most frequently used payment method at the point of sale, accounting for 59% of transactions, this proportion has fallen by 20% since 2016. Conversely, card payments were used in ⅓ of in-store transactions, compared with ⅕ in 2016. At the same time, contactless card payments are becoming more widespread (from 41% of all card payments in 2019 to 62% in 2022). We can also see that the share of mobile payments, previously insignificant, will represent 3% by 2022.
- In terms of value, cards accounted for a higher proportion of payments than cash (46% versus 42%), in contrast to 2016, when cash continued to dominate (54% versus 39%). While cash is most often the medium of choice for low-value payments, consumers prefer electronic methods for payments over €50. The share of online payments (in non-recurring transactions) has risen from 6% in 2019 to 17% in 2022, with strong growth in transactions dedicated to the purchase of food and daily supplies by supermarkets and restaurants.

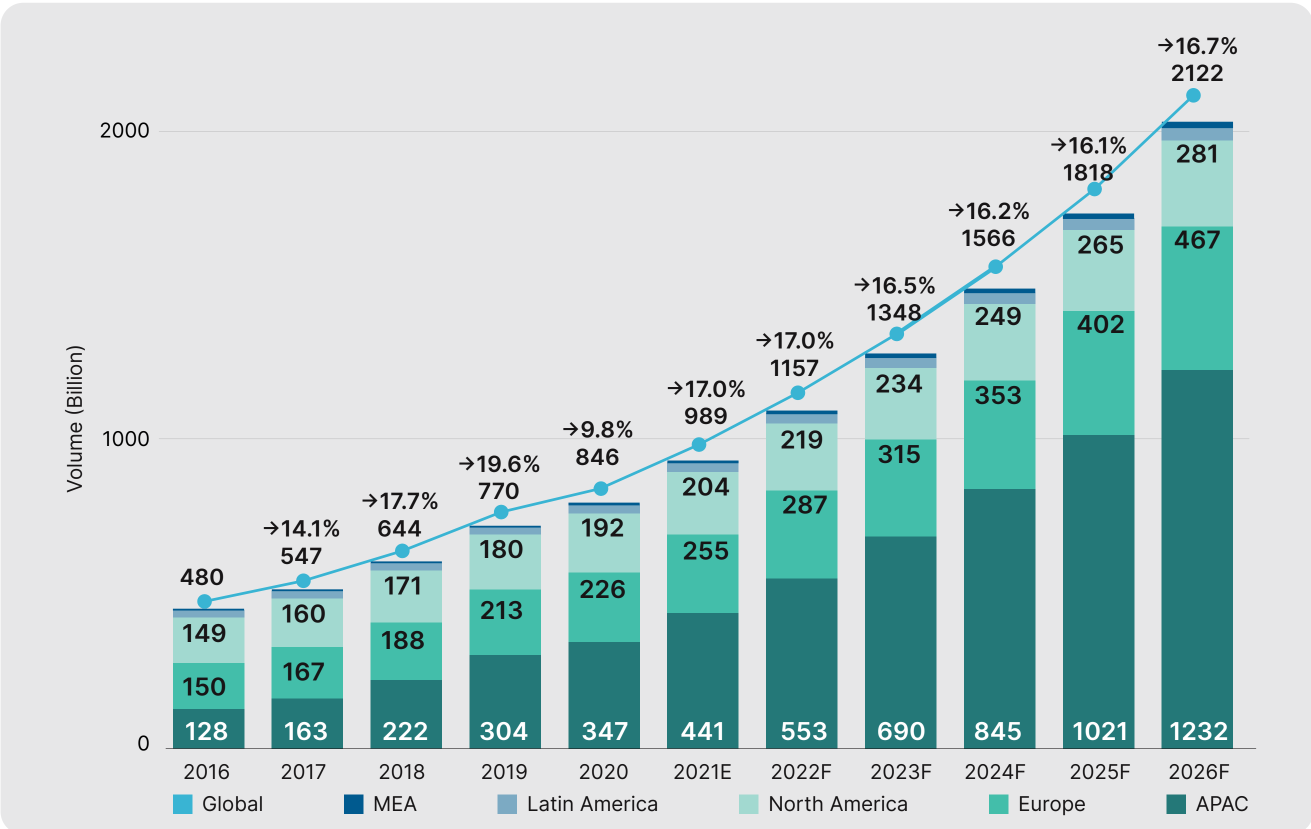
Figure 1. Change in share of cash transactions at points of sale (in terms of number transactions), 2019-2022 (%).



Source: European Central Bank, Study on the payment attitudes of consumers in the euro area, SPACE 2022.

This picture provided by the ECB clearly reflects only a very transitory state, as new payment methods and interfaces are emerging at a high rate, with more and more innovations fuelling this diversification of payment transactions. Capgemini (2022) forecasts that non-cash transactions will continue to grow at a fast pace (+17%/year), doubling in volume between 2021 and 2026.

Figure 2. Worldwide non-cash transactions volume (2016-2026, in billions).



Source: Capgemini, World payments report 2022. Winning with SMBs: Optimising technology and data to drive deep engagement, 2022.

With the rise of the Internet, digital payments have gone from being a technological novelty to one of the main payment options, their adoption being accelerated by the development of new technologies (Internet of Things, blockchain, near field communication, chatbots, QR codes, metaverse in the future, ...), by regulations sometimes favourable to their adoption (for example, in the euro zone, the DSP21) and even certain policies designed to limit the use of cash (as in Sweden[2]). Added to this is the growing penetration of smartphones and the use of social media, which are conducive to the development of instant peer-to-peer (P2P) payments.

Another phenomenon within this payments trend is the interest shown by central banks in the creation of digital currencies (Central Bank Digital Currencies, CBDC). According to the International Monetary Fund, this prospect is being considered in around a hundred countries, with several central banks having already launched pilot projects or even issued a CBDC (IMF 2023). Even if the added value of these orientations taken by central banks is not – at this experimental stage – obvious, it also illustrates the digital transition of payments.

Box 1. Adoption of digital payments accelerated by COVID-19.

The Covid-19 pandemic has had a significant impact on the adoption and acceleration of electronic payments. As a result of social distancing measures, physical shop closures and concerns about the transmission of the virus through cash, more consumers have opted for electronic payments for their purchases and financial transactions. Peer-to-peer electronic payments, such as money transfers between friends and bill payments, have also increased. 31% of Europeans said they were using cash less often than before the pandemic and 37% of consumers were buying goods online more often than before the pandemic (ECB 2022). According to the Fevad-Médiamétrie quarterly barometer of e-commerce audiences in France (4th quarter 2020), almost 4 out of 10 cyber shoppers increased their online purchases in 2020, with 85% of them saying they spent more than usual. Another indication is that the spread of the pandemic has led to a ¼ increase in the rate of daily downloads of finance-related mobile applications. (Fu & Mishra, 2022). It is also in this context that companies have begun to promote and encourage NFC payments through loyalty programmes and exclusive discount offers.

However, this does not mean that these developments herald a cashless society. The majority of consumers in the eurozone consider that it is still essential to have cash as a means of payment, and place particular emphasis on anonymity and the protection of privacy, even though it was possible to pay with instruments other than cash in ⅘ths of transactions in 2022 (ECB 2022). Most European consumers are also satisfied with their access to cash, with 90% saying that it was fairly or very easy to go to an ATM or bank.

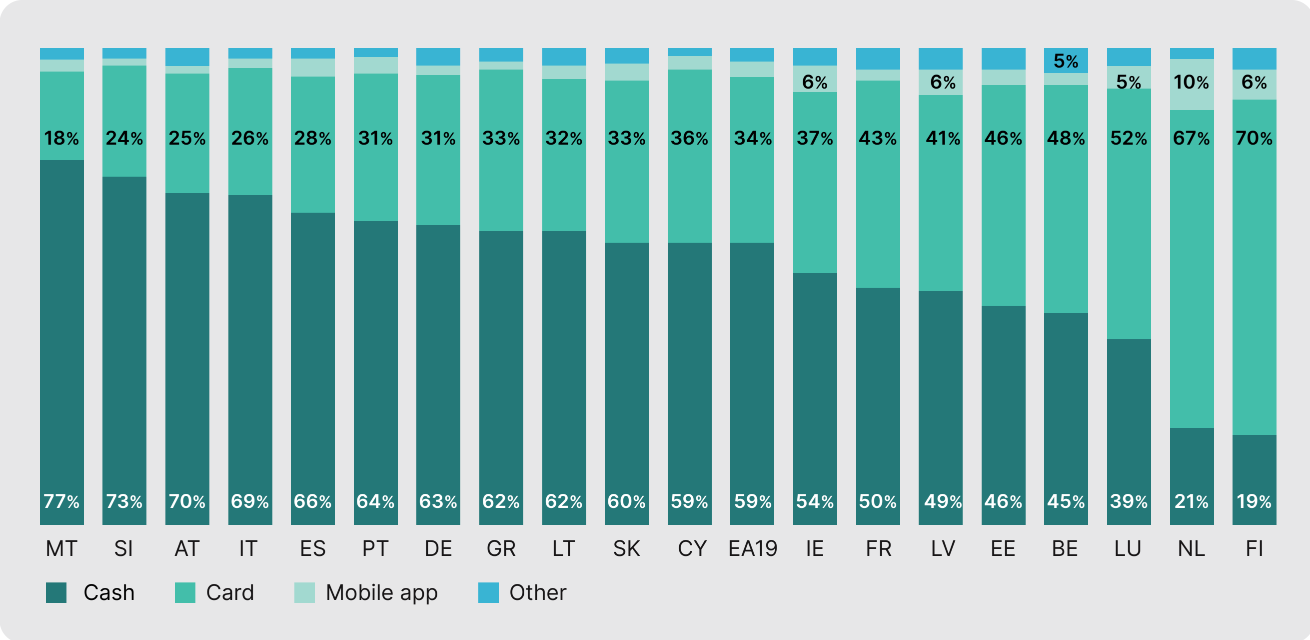
As Schwartz & Messaoui (2021) point out *"measured by the value of coins and banknotes in circulation or by the ratio between this value and GDP, the demand for cash is constantly increasing worldwide, with a few exceptions (China, Sweden, etc.). For the last twenty years, cash in circulation has been rising steadily by 6 to 8% a year in the case of the euro and the US dollar"* (p.1). All in all, Figure 3 above all reflects the extraordinary heterogeneity of practices, with countries where the disappearance of cash is well advanced (Finland, Netherlands) and others where notes and coins remain predominant in everyday use (Malta, Slovenia, Austria).

Nevertheless, the trend is clear and, whatever the payment culture, cash is part of an extraordinarily diverse landscape. While the prospect is not really that of a "cashless society", these transformations call for vigilance in terms of social inclusion and, more broadly, maintaining freedom of choice (Schwartz & Messaoui 2021; Jaiswal et al. 2023).

1 The Second European Payment Services Directive (PSD2), which has been in force in the European Union since 13 January 2018, includes a set of regulatory provisions aimed at regulating the provision of payment services and strengthening the security of payments at European level. More specifically, this directive has a significant impact in three areas: Consumer rights: PSD2 extends consumer rights by introducing greater transparency in payments as well as new rules for surcharges, currency conversion and complaints handling. Security: PSD2 introduced the strong customer authentication (SCA) criterion which, among other security measures, includes a two-factor identification requirement. Third-party access: this is one of its most important legislative effects, as PSD2 allows third parties to access account information held by banks.

2 Notably, in 2017, the Swedish government enacted a law that allows merchants to refuse cash payments for transactions over 1,000 kronor. And in 2020, it launched an awareness campaign to encourage people to use electronic means of payment rather than cash.

Figure 3. Breakdown of payment instruments used at points of sale as a proportion of the number of transactions (2022).



Source: European Central Bank, Study on the payment attitudes of consumers in the euro area, SPACE 2022.

In summary: The digital payments front is evolving rapidly, notably in the eurozone. Although cash still predominates in terms of the number of transactions and monetary volumes, its use is gradually declining. The rise of the Internet and new technologies, such as blockchain, autonomous payments, connected objects, chatbots, etc., is contributing to the rapid adoption of digital payments. In addition, the Covid-19 pandemic has accelerated this trend due to social distancing measures, favouring electronic payments for purchases and financial transactions. However, despite this digital transition, the total disappearance of cash is not imminent. The majority of consumers in the eurozone still consider cash to be essential, stressing in particular its anonymity and protection of privacy. Payment habits still vary widely from country to country.

1.2. On the environmental front: a need for refinement in impact measurement.

The organisation of payment circuits has one part that is visible to users (plastic bankcards, payment terminals in shops, cash-in-transit lorries, etc.) and another part that is invisible to them (telecommunications networks, data centres, coin and banknote manufacturing plants, etc.). Assessing this environmental footprint of payment circuits, with the aim of informing private and public choices, involves different levels of complexity:

- Firstly, because, as we have just seen, the diversity of payment solutions is considerably enhanced by the deployment of digital technologies, and the aim is to understand a "bouquet" of solutions rather than a single solution. In other words, these analyses cannot be confined to the cash circuit, and it is unsurprisingly in this area that the bulk of the – fairly fragmented – assessments have been concentrated at this stage.
- Secondly, because the use of means of payment is likely to vary considerably from one country to another and, moreover, part of the environmental performance will depend on local factors (carbon footprint of the electricity system, organisation of road transport, etc.) so that it will not be possible to extrapolate from results obtained from an analysis carried out in a specific context (or, at least, we will have to proceed with caution).

Central banks have initiated different studies aimed primarily at measuring the environmental footprint of the cash circuit.

Following the introduction of polymer notes in 2016, the Bank of England commissioned a report examining the carbon footprint of paper and polymer notes (BoE 2017). The report analysed the 'cradle to grave' life of paper and polymer £5 and £10 notes. The study concludes that, over their entire life cycle, polymer £5 and £10 banknotes have a lower carbon footprint (less greenhouse gas emissions, by an order of magnitude of around 10%) than paper banknotes of the same denomination, due to greater durability (2.5 times greater due to their greater durability[3]).

The Bank of Canada (BoC 2021) also assessed the life cycle of banknotes to confirm that polymer banknotes have a lower environmental footprint than paper banknotes. In each category, the results showed that the environmental impact of polymer banknotes would be at least 30% lower than that of paper banknotes. In Canada, the benefits of using polymer are largely related to the transportation of notes across the country, with fewer trips to and from the Bank's note distribution centres.

In the same spirit, the Swiss National Bank (BNS 2022) compared the progress made between the eighth and ninth series of banknotes. The study reveals that the overall environmental impact of the ninth series is just under 20% lower than that of the eighth: this is also explained by the fact that the banknotes are much more resistant to wear and tear (by using a substrate composed of both high-quality cotton raw materials and polymers). Among the factors also put forward, the increased use of low-carbon electricity both in the banknote production process and in transport is also a differentiating factor.

While the European Central Bank provides less information in its environmental analysis of these processes, it does provide European citizens with a useful comparison of the impact of the common currency in the eurozone. As euro banknotes are designed to be used on a daily basis, their environmental impact was compared with the ones caused by other daily activities. The assessment concluded that the total environmental impact caused by the 3 billion euro banknotes produced in 2003 was equivalent to the environmental impact of each European citizen driving a car one kilometre or leaving a 60W light bulb on for 12 hours (ECB 2023)[4].

The work of Delnevo & Smyth (2020), again for the UK, is interesting in that it focuses on the specific footprint of the ATM network. This report stresses that, while the transport of cash throughout its life emits significant quantities of GHGs, it is the production of the electricity needed to operate ATMs that is predominantly responsible for this, with the report's analysis indicating that more than 60% of the carbon footprint of a banknote comes from the energy used to operate ATMs alone. This means that the carbon footprint of ATMs needs to be reduced as a matter of urgency. With this in mind, the study also shows the impact of rationalising the ATM network: each thousand ATMs removed should reduce the energy consumption of the ATM fleet by around 2%. But it should also be noted that, given the commitments made in the UK – and elsewhere in the European Union – in terms of decarbonising electricity systems, this dimension of the carbon footprint is set to diminish as these efforts materialise.

3 The assumption used here is fairly conservative, so it is likely that the advantage of polymer banknotes will be comparatively even greater.

4 Furthermore, Yousef et al (2019) point out that very few studies have focused on recycling due to the strict security system that exists in the banknote production process. Consequently, incineration remains the most widely used process for the disposal of end-of-life banknotes and banknote production waste.

Box 2. How can banknotes be made greener?

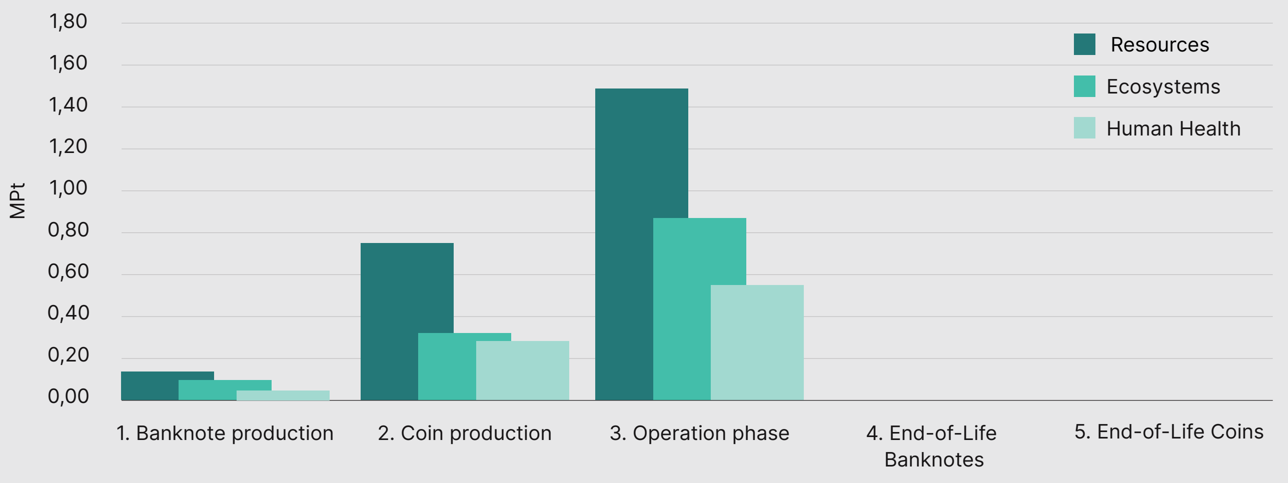
Giesecke+Devrient (G+D)[5] has defined the prototype of a "green" banknote, i.e. a banknote whose carbon and water footprints will have been considerably reduced during its production and entry into circulation. As part of a global approach, the entire life cycle of a banknote will be covered. This includes alternative fibres, newly developed inks and other recycled raw materials covering all the major value streams in production (substrate, foil and printing). This green banknote will have the following performance: 29% less CO_2 than polymer banknotes, 86% less plastic than polymer banknotes for a similar lifespan. G+D has a facility in Malaysia for the production of banknotes and other security documents. At the end of 2020, it had installed more that 4,000 solar panels on the roofs of the factory, totalling 1.7 MWp covering an area of almost 9,000m². The energy produced covers 10% of the plant's electricity needs and saves 638,000kg of CO_2e every year.

Among the impact analyses produced by central banks, the one produced by the Dutch Central Bank (Hanegraaf et al. 2018) is worth a closer look, as it sets a benchmark[6]:

- This study quantifies the impact of the Dutch cash payment system on the environment and climate change using a life cycle assessment, examining the impact of coins and banknotes.
- The cash payment system was divided into five sub-systems: banknote production, coin production, the operating phase, the end-of-life of banknotes and the end-of-life of coins.
- The environmental impact of the Dutch cash payment system in 2015 was 17 million kg $eqCO_2$. For an average single cash transaction, the environmental impact was 4.6g $eqCO_2$.
- The operating phase (ATM energy consumption, transport of notes and coins, etc.) (64%) and the coin production phase (32%) had the greatest impact on the environment, while the operating phase also had the greatest impact on climate change (88%).

Finally, the analysis of the scenarios shows that reductions in environmental impact (51%) and climate change impact (55%) could be achieved by implementing various measures: reducing the number of ATMs, encouraging the use of renewable energy in ATMs, introducing hybrid trucks for cash transport, etc.

Figure 4. Results of the evaluation conducted by the Dutch Central Bank (2018).



Source: Hanegraaf R. et al, Life cycle assessment of cash payments, DNB Working Paper No. 610, 2018.

Legend: The impact assessment method used in this study takes into account three final indicators (human health, ecosystem quality and resources) converted into a single environmental indicator, the eco-indicator, with the value of eco-indicator expressed in points (Pt). The advantage of this indicator is that it makes it possible to compare the environmental impact of products that are substitutes, such as cash payments and debit card payments.

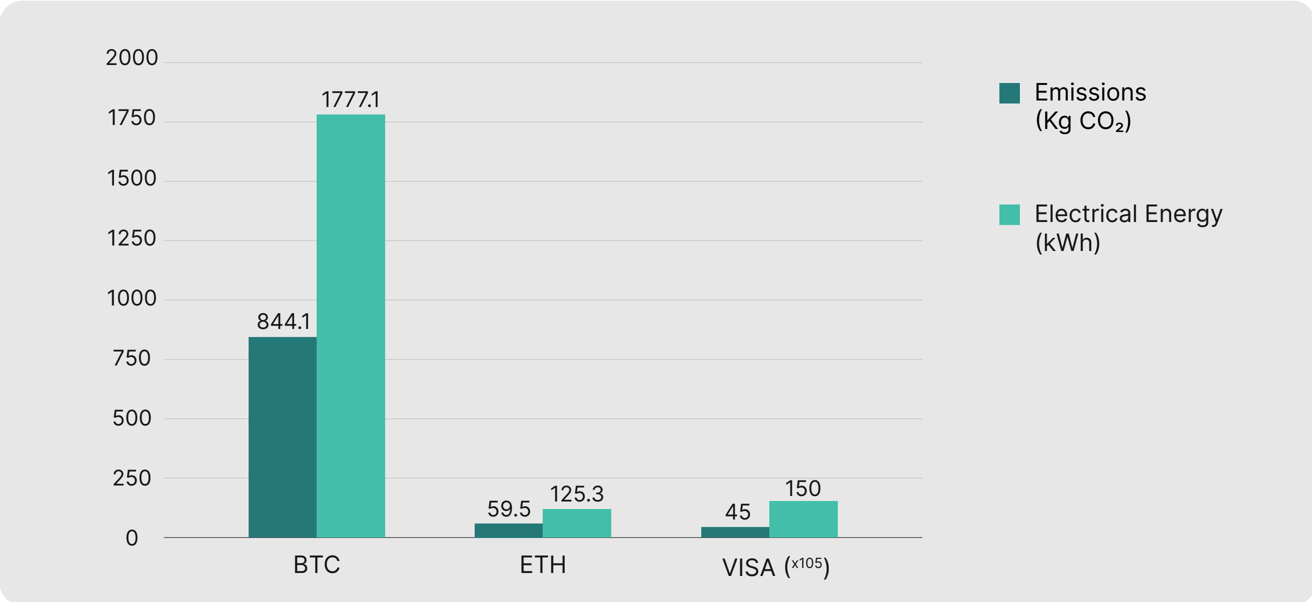
5 Giesecke+Devrient (G+D) is an international technology group based in Munich which, in addition to printing banknotes, securities and passports, also specialises in smart cards and security solutions.

6 Furthermore, as we will see in the next section, the original analyses commissioned by Worldline largely refer to the methodology used by the Dutch Central Bank.

These impact analyses have recently been extended with the spread of cryptocurrencies. Depending on the protocol used, some of these currencies can require high levels of computing power, as is the case with Bitcoin. To assess the environmental impact of Bitcoin, we need to understand the underlying blockchain technology: to create a new “block” in the chain, “miners” compete to resolve a complex mathematical puzzle. The first one to finish is rewarded. Each node then verifies the proposed block’s validity before adding it locally to its own ledger. The environmental impact is directly proportional to the computing power required for all the nodes to compete, attempting to solve the puzzle, and the validation by all nodes before updating their ledger, leading to a corresponding rise in electricity consumption. The University of Cambridge has developed an index[7] that measures Bitcoin’s real-time power consumption. By mid-2023, this consumption accounted for 0.6% of the world’s electricity and 0.14% of greenhouse gas emissions (approximately 70 million tonnes of CO_2e).

These concerns have led to a body of a literature that compares the environmental impact of cryptocurrencies with that of conventional currencies. According to Pagone et al (2023), the carbon footprint of Bitcoin is 4 to 5 times greater than the combined emissions of all forms of traditional currency in one year. Kohli et al. (2023) compared the carbon footprint and electricity consumption of a transaction carried out via Bitcoin and Visa (as well as Ethereum), with the results summarised in the figure below showing remarkably contrasting outcomes[8].

Figure 5. Electrical energy consumption and CO_2 emissions per transaction for Bitcoin, Ethereum and Visa.



Source: Kohli et al., An analysis of energy consumption and carbon footprints of cryptocurrencies and possible solutions, Digital Communications and Networks, 2023.

In summary: The environmental footprint of payment circuits involves both visible components, like plastic bankcards and payment terminals, and invisible components, such as telecommunications networks and data centres. Assessing this footprint requires considering the diversity of payment solutions enabled by digital technologies and understanding a range of solutions, rather than just cash circuits. Central banks have conducted studies to measure the environmental impact of banknotes. For instance, the Bank of England found that polymer banknotes have around 10% less greenhouse gas emissions compared to paper banknotes of the same denomination due to their greater durability. The Bank of Canada similarly concluded that polymer banknotes have at least 30% lower environmental impact than paper banknotes, mainly due to reduced transportation needs. The Dutch Central Bank conducted an LCA finding that the operating phase and coin production had the most significant environmental impact. Implementing various measures like reducing ATMs and using renewable energy could lead to substantial reductions in environmental and climate change impact. Additionally, cryptocurrencies, such as Bitcoin, have raised concerns due to their high computing power requirements, leading to increased electricity consumption and a significant carbon footprint compared to conventional currencies.

7 Cambridge Bitcoin Electricity Consumption Index (CBECI), ccaf.io/cbnsi/cbeci.

8 The density of Bitcoin’s electricity consumption is linked to the “proof of work” protocol. By comparison, “proof of stake” is a method of validating transactions on the blockchain that enables a distributed consensus to be reached by means of incentives, without mobilising electro-intensive computing power.

2. Scope and added value of the life cycle assessments initiated by Worldline.

There is clearly a gap between the need to understand the environmental impact of payments (in the context of the profusion of new digital methods) and the measures available, which are fairly limited at this stage, as we have pointed out, in particular to gain a better understanding of the specific footprint of the digital components of systems (and, beyond that, rapidly evolving digital payment methods). This is detrimental both in terms of guiding consumer choices in their use of payment methods, enlightening the players in the industrial ecosystem and merchants, and of course guiding public policy.

2.1. Motivation and objectives of the LCAs commissioned by Worldline.

It is in this context that Worldline has commissioned original LCAs, both to shed light on this debate and to better understand the impact of its activities, in line with its commitment to the coalition NegaOctet[9] (which aims to develop the first Life Cycle Assessment framework for digital services with a view to their eco-design). For Worldline, this approach is also part of the TRUST 2025 CSR programme, which includes targets for reducing its carbon footprint, with a result in 2022 of almost -50% compared with 2019 for scopes 1 and 2[10].

Generally speaking, the assessments commissioned by Worldline had the following objectives:

- On the one hand, compare the environmental footprint of an in-store bankcard transaction with its online equivalent.
- And, secondly, to compare the results obtained with a cash transaction.

Centrally, Worldline's objective was to determine a threshold for the number of payments made for a withdrawal, above which there is an environmental benefit to making cash payments.

The methodology used was inspired by the study carried out by the Dutch Central Bank (Hanegraaf et al. 2018), which marked an important step in measuring the environmental footprint of payments. Naturally, while such a life cycle assessment is necessarily very granular (leading to numerous results relating to the different dimensions of the environmental impacts considered), the results here must be interpreted with caution, given the many assumptions required to develop the analysis and, above all, the dependence on the context (in this case that of Belgium), which limits the scope of extrapolations.

Nevertheless, it seems to us that all these new assessments of the life cycle of payments constitute an original contribution to the debate. They very usefully extend the approach of the Dutch Central Bank and offer valuable lessons regarding the most 'virtuous' uses, in environmental terms, of means of payment. These assessments also open up prospects for improvement (both in optimising these uses, but also in improving the eco-design of equipment).

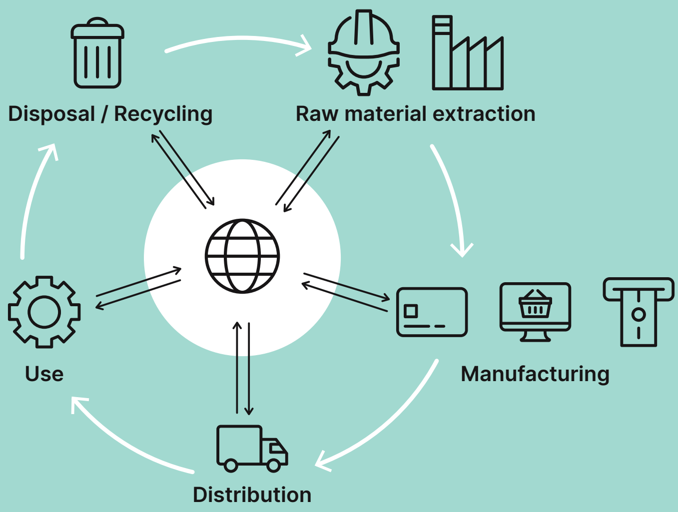
We will highlight here the key points of the assessments and the main conclusions that we feel will enrich the debate. It is also interesting to note that this contribution comes from a player in the payments industry ecosystem (giving access to these data to carry out these LCAs), and not from central banks or academic research, as has been mainly the case until now.

9 To demonstrate the relevance of the NegaOctet benchmark, a pilot phase has been organised, during which some twenty companies had the opportunityto test the benchmark and assess the environmental impact of their digital services. They also received support in identifying eco-design solutions. Worldline is one of them.

10 The result of 36 months of research by LCIE Bureau Veritas, APL Data Center, GreenIT.fr and DDemain, NegaOctet makes it possible to measure and significantly reduce the environmental impact of digital services throughout their life cycles. It offers a free or paid database and a tool that automates the calculation of environmental KPIs (global warming, resource consumption, pollution, etc.). The NegaOctet repository is continuously being enriched and improved (creation of new data and maintenance of the database).

Box 3. Steps in environmental life cycle assessment.

LCA is a method of evaluating the environmental impacts of a product or service over its entire life cycle, from the extraction of raw materials to final disposal. LCA is a systematic approach to identifying and assessing the potential environmental impacts of a product or service, and to comparing different design, production, use and disposal options (in accordance with ISO 14 040:2006 – ISO 14044:2006). Several environmental indicators need to be considered systematically, including global warming potential, depletion of abiotic resources, photochemical ozone creation, water, air and soil pollution, human ecotoxicity, biodiversity, etc. The list of indicators is not fixed, but depends on the sector of activity.



The stages in a life cycle assessment are as follows:

- Define the objectives and scope of the study;
- Collect data on the system (raw materials used, energy consumed, greenhouse gas emissions and waste generated);
- Establish the life cycle inventory (compile the data collected in a database, to identify the system's main material and energy flows);
- Assess the environmental impact (use the inventory data to evaluate the environmental impact of the system, using impact factors);
- Interpreting the results of the study (identifying the main sources of environmental impact and making decisions on the design, production, use and disposal of the product or service).

2.2. Step 1: compare in-store and online card payments.

In the first study commissioned by Worldline, the objective was to evaluate the environmental footprint of a financial transaction carried out in-store using a payment card (specifically, the Bancontact domestic card in Belgium) and compare it to the environmental impact of a financial transaction carried out online. The focus was on identifying the primary contributors to the environmental impact of these financial transactions and understanding the sensitivity of the results to certain parameters.

Description of the system associated with the service:

- The system studied is the one enabling a financial transaction to be carried out from the cardholder's payment card through the merchant's payment terminals to the infrastructure enabling the exchange of assets to be implemented.
- In the case of a financial transaction carried out by payment card, the players involved in this operation are the cardholder, the merchant, the payment card issuer, the acquirer (who collects the funds on behalf of the merchant), etc.[11].
- The functional unit chosen is based on "small" retailers with a few terminals (or even just 1)[12].
- The system handles the entire financial transaction, from payment by the cardholder to transfer of the money to the merchant's account.

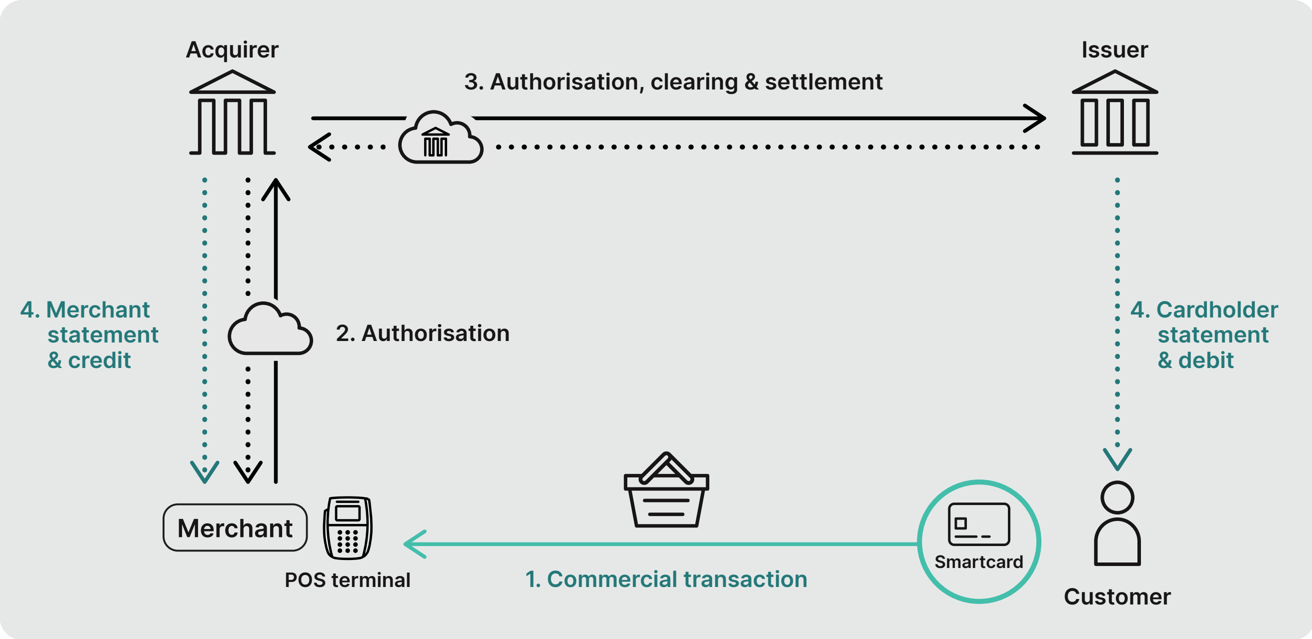
The scope has been reduced to:

- Provision of the payment card.
- All transactions carried out in-store on the payment terminal or on the payment page.
- All transactions carried out by the cardholder.
- All IT transactions processed by Worldline.
- An estimate of the impact associated with the use of the communication network.

11 As a Payment Service Provider (PSP), Worldline is both issuer and acquirer in Belgium.

12 But not a so-called distributed configuration with a server and a checkout line. Similarly, the possible impact of the merchant's checkout is not considered.

Figure 6. Flow chart of an in-store payment card transaction.



Source: DDemain, Analyse du cycle de vie de deux solutions de paiement : paiement en magasin, paiement e-commerce, Étude commanditée par Worldline, 2022.

In store scenario – main assumptions:

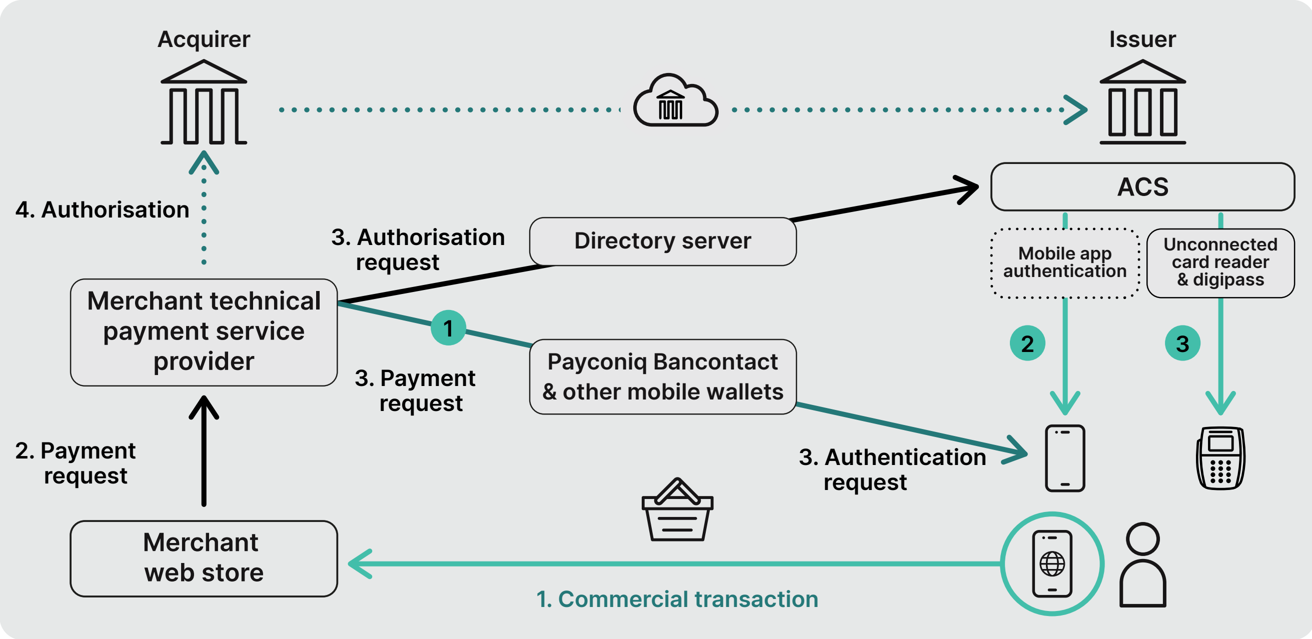
- Scenario representative of Belgian usage
- Payment by card – 1 card has a lifespan of 4 years and 77 transactions per year
- Payment terminal: Yomani (Pinpad + Merchant unit)
- Issue of 2 tickets
- Merchant connection via DSL network

Main results in terms of carbon footprint[13]:

- An in-store transaction generates 2.45g $eqCO_2$.
- The printing of the ticket (42%), the payment card (34%) and the payment terminal (20%) account for most of the footprint.
- In comparison, the weight of the platforms (issuer and acquirer) and the ADSL network is negligible.
- Different variants lead to marginally different results:
- Use of an alternative payment terminal – Ingenico Move 5000: 2.33g $eqCO_2$.
- Use of a 3G network: 2.47g $eqCO_2$.
- Payment via smartphone without card (including Mobile App Auth + Smartphone Impact): 2.52g $eqCO_2$.
- Payment via smartphone without card (including smartphone at marginal cost): 2.01g $eqCO_2$.
- Sensitivity analyses showed that results varied significantly according to:
    - The number of times bankcards are used: doubling the number of bankcards reduces the impact of the card per transaction by 20%.
    - The number of daily transactions per payment terminal: doubling this number reduces the impact of this equipment by 10%.
    - In total, taking into account the 1,450,000,000 in-store transactions carried out by Worldline in 2019, the overall impact is 3,550 tonnes of $eqCO_2$.

13 We focus here on the carbon footprint of processes, but LCA also covers the following dimensions: ADPe – Abiotic Depletion Potential element; A - Acidification, PM -Particulates matter; IR – Ionising radiations; ADPf – Abiotic Depletion Potential fossil; WU – Water use; MIPS – Material input per services unit. See appendices for more detailed results.

Figure 7. Flow chart of an online payment card transaction.



Source: DDemain, Analyse du cycle de vie de deux solutions de paiement : paiement en magasin, paiement e-commerce, Étude commanditée par Worldline, 2022.

E-commerce scenario – main assumptions:

- Scenario representative of Belgian usage.
- Payment by mobile phone.
- Physical/mobile authentication split: 87/13%.
- 8 transactions per year for an individual authentication box.
- Cardholder connection via 3G network.

Main results in terms of CO_2:

- An online transaction generates 11.9g eqCO_2.
- The authentication device accounts for 75% of this footprint, the smartphone for 15% and the card for 7%.
- As for sensitivity, it turns out that the results vary significantly according to:
- Eliminating authentication by terminal would reduce the footprint of a transaction to 3g eqCO_2.
- Similarly, increasing the number of authentications per year (from 8 to 24) would halve the terminal footprint per transaction[14].
- Of all the analyses carried out elsewhere, including those on the impact of the electricity mix on data centre consumption (comparing Belgium with France, the latter being less carbon-intensive), the following has no real impact on the carbon footprint of a transaction.
- In total, considering the 100,000,000 in-store transactions carried out by Worldline in 2019, the overall impact is 119 tonnes eqCO_2.

In summary: The first study commissioned by Worldline compared the environmental footprint of in-store and online card transactions in Belgium. For in-store transactions, the footprint was 2.45g CO_2e, mainly due to ticket printing (42%), the payment card (34%), and the payment terminal (20%). The impact of the platforms (issuer and acquirer) and the ADSL network was negligible. In the e-commerce scenario, the footprint for online transactions was 11.9g CO_2e, with the authentication device the main contributor (75%), followed by the smartphone (15%) and the card (7%). The results were sensitive to the elimination of the authentication device and the increase in the number of authentications per year.

14 As already mentioned, it should be noted once again, however, that while a development of this nature reduces emissions within the payment system perimeter, as soon as it is associated with more acts of purchase, it is likely, on the other hand, to lead to an increase in emissions outside this perimeter.

2.3. Step 2: extend the analysis to cash transactions.

The second study commissioned by Worldline[15] involved:

- Evaluate the environmental footprint of a cash withdrawal transaction in Belgium (the case of France is also included in the sensitivity analysis).
- Identify the main contributors to the environmental impact of this financial transaction.
- Assess the sensitivity of the results to certain parameters.
- Assess the applicability of the conclusions in other contexts.

As described above, the chain of players involved in processing a financial transaction is complex. It includes the cardholder, the merchant, the issuer of the cash withdrawal card, the producer of the cash (notes and coins) and the acquirer.

We have reduced the scope according to the data that can be collected:

- The provision of cash withdrawal cards (equivalent to the provision of payment cards in the previous study).
- Production and provision of cash (banknotes and coins).
- All transactions carried out by the cardholder.
- All IT transactions processed by Worldline.
- An estimate of the impact associated with the use of the communications network.
- Cash transactions carried out by banks are not considered.

Life cycle stages included in the scope:

- Digital service: stages identical to those in the study of in-store payments.
- Withdrawal card and receipt production.
- Production and use of ATMs.
- Production of banknotes and coins.
- Distribution of banknotes and coins from the manufacturing centre to the storage centre, and then to the ATMs.
- End of life of banknotes and coins.

Main hypotheses:

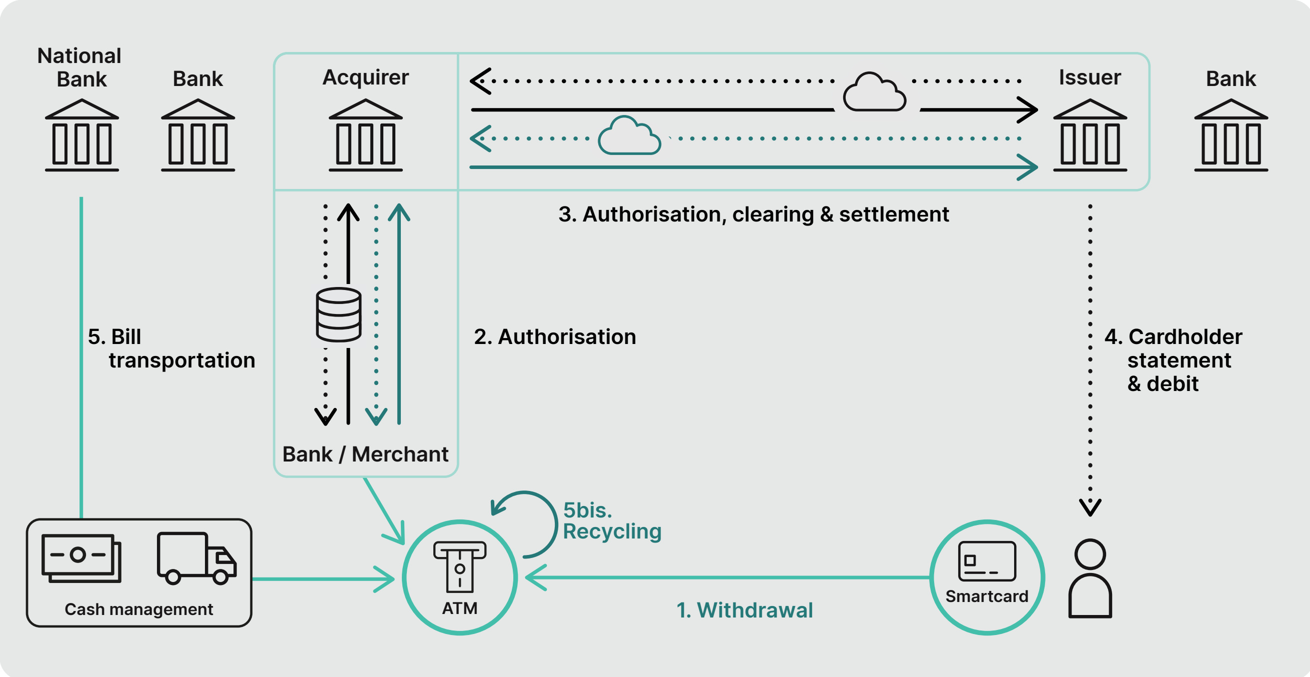
- Scenario presenting the scope and uses in Belgium.
- Only 20% of the cash produced is intended for cash payments.
- ATMs are only supplied with banknotes.
- 1 card has a lifespan of 4 years and carries out 65 transactions per year.
- A ticket is printed for 2/3 of withdrawals.

The main results:

- Assuming that 20% of the cash produced is used to make cash payments, and that a single withdrawal is used to make a single payment, the impact of a cash payment is 19.5g CO_2eq.
- Most of the impact (80%) is due to the ATM (manufacture of the ATM and energy consumption during use) representing an emission of 15.6g CO_2eq.
- The production of cash and the cardholder (represented by the cash withdrawal card and the cash withdrawal slip) contribute to almost all of the remaining impacts:
    - 2.24g CO_2eq for the production of cash.
    - and 1.17g CO_2eq for the cardholder.
    - With the exception of the number of transactions per withdrawal, no other parameter has a significant influence on the carbon footprint of the operation (a point we will discuss in the next section).
    - In terms of the number of transactions, the overall impact in 2019 was as follows, 4,680t CO_2eq.

15 DDemain & Solinnen, Analyse du Cycle de Vie d'une transaction financière effectuée par argent liquide, Étude commanditée par Worldline, 2022.

Figure 8. Flow chart of a cash transaction.



Source: DDemain & Solinnen, Analyse du Cycle de Vie d'une transaction financière effectuée par argent liquide, Étude commanditée par Worldline, 2022.

In summary: The second study commissioned by Worldline showed that the environmental impact of a cash withdrawal in Belgium is 19.5g CO_2eq. Most of the impact (80%) is due to the ATM. The production of cash and the cardholder contribute to the rest of the impact. The environmental impact of cash payments can be reduced by increasing the number of transactions carried out with a single cash withdrawal, using more energy-efficient cash dispensers, increasing the life of the cash withdrawal card and reducing the frequency of cash withdrawals.

2.4. Step 3: compare all payment methods according to usage.

The various studies that have been produced have produced a number of environmental results, as is to be expected from an LCA. Continuing to focus here specifically on the climate dimension, and therefore the carbon footprint, the main result of the comparison established by these studies is as follows:

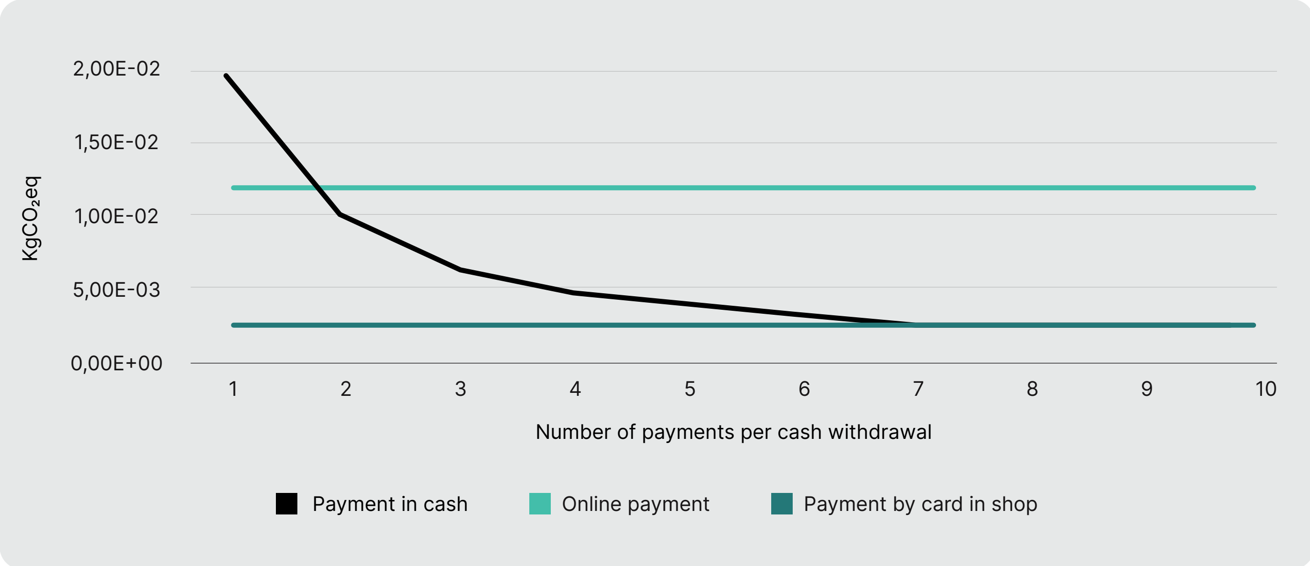
- For 2 or more cash payments per withdrawals, the impact of cash payments on the climate change indicator is less than that of online payments.
- Finally, from around 8 payments per cash withdrawal, the impact of cash payments on the climate change indicator is less than that of card payments.

Bearing in mind that these LCAs are very complex processes, we will focus less on the numerical value of these thresholds (2 and 8 transactions) than on their very existence, which sheds light on the debate on the hierarchy of means of payment – with regard to their carbon footprint – and therefore offers results that enhance the "state of the art":

- Payment by card has the lowest carbon footprint, a performance that can be further improved, in particular (and very significantly) by not issuing paper tickets, or by keeping the same payment card for a longer period of time.
- The footprint of online payments is much larger than that of in-store card payments, but can be similar if an authentication box is not used (using smartphone authentication instead). However, even when all the parameters are optimised, this method of payment has a larger footprint than payment by card in a shop.
- The efficiency of cash payments follows a different logic, as soon as it is necessary to make a withdrawal at an ATM, operation which corresponds to a sort of "fixed cost". This method is only effective if it then leads to a greater or lesser number of "small payments". And this, with the method used here, without taking into account the impact of the journey to the ATM.

In the final section of this document, we will endeavour to draw lessons from these life cycle assessments so as to come up with recommendations for moving towards 1g eqCO_2 transactions.

Figure 9. Comparison of the 3 payment methods according to their carbon footprint and the number of transactions carried out.



Source: DDemain & Solinnen, Analyse du Cycle de Vie d'une transaction financière effectuée par argent liquide, Étude commanditée par Worldline, 2022.

In summary: The LCAs commissioned by Worldline offer added value in that they make it possible to rank payment methods according to their carbon footprint and conditions of use. The identification of threshold effects – even if their level is likely to vary significantly depending on consumption profiles (volume of cash withdrawals in particular) – is a useful contribution to our knowledge of the environmental footprint of payment methods. In addition, these LCAs make it possible to identify the main leverage effects for reducing these impacts.

2.5. To what extent can the lessons learned from these LCAs be used outside their original scope?

As we have just indicated, the LCAs commissioned by Worldline are useful in that they provide a basis for a comparative logic between means of payment and pave the way for further developments in this direction. Compared with a literature that is largely focused on the cash cycle, they open the door to a higher order of complexity, which particularly implies discussing the scope of the results, but also their limitations.

Some of these limitations are linked to the process that was used, with two successive studies that it would probably have been preferable to integrate into one (with greater methodological consistency).

Others stem from the analytical complexity intrinsic to this type of exercise, since it involves studying entire systems and not "simply" the life cycle of a product. In particular, this has led to the approximation of certain data, since it was not directly available in the Belgian context:

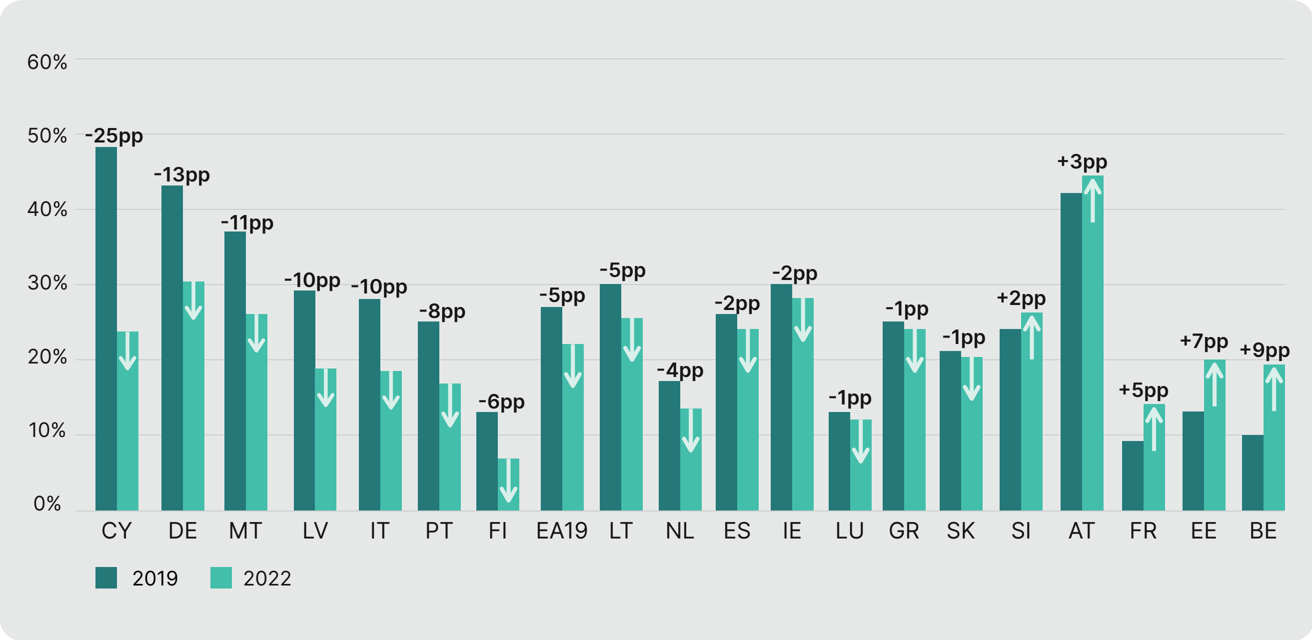
- French data were used for the transport of cash in vans. For banknote and coin production and end-of-life, Dutch data were used[16].
- These two choices are cited only to illustrate some of the choices that had to be made, of necessity, given the complexity of the system to be analysed (without prejudging the impact of these choices on the final results).

Other limitations on the ability to extrapolate from the results proposed by these analyses are linked to the specific features of the Belgian context, given that, even in a highly integrated area such as the euro zone, heterogeneity predominates in terms of payment preferences, as we have already emphasised above.

By way of illustration, we will see in the Figure below that Belgian consumers stood out as those who, contrary to the European trend, strongly increased their preference for cash during the health crisis (and that they are even those who have deviated the most from the European trend). Over and above these changes in preferences, the various European states are characterised by their topography, which mechanically has an impact on certain elements of the payment system (particularly the cash logistics chain, as highlighted by the Bank of Canada study (BoC 2021)).

16 In general, the Dutch Central Bank's baseline study (Hanegraaf et al. 2018) provided essential support for the LCAs, both in terms of methodology, as already mentioned, but also when data was missing on the Belgian side.

Figure 10. Preferences for cash, 2019 vs. 2022.



Source: European Central Bank, Study on the payment attitudes of consumers in the euro area, SPACE 2022.

In addition, the method is based on the assumption of a "representative consumer", likely to reflect the "average" behaviour within a community. It is essential to bear this characteristic in mind, emphasising that, particularly for cash, behaviour is likely to vary very significantly depending on the socio-economic profile of consumers (unit volume of withdrawals, whether or not the resulting payments are split, etc.).

It is true that sensitivity analyses make it possible to introduce "variety", clearly showing that some of the parameters under the direct control of consumers (e.g. the use of smartphones and the length of time they are kept, and in future the acceptance of a transaction without a ticket, etc.) have a real impact on the carbon footprint of transactions.

Lastly, and perhaps most importantly, it is essential to view these results as a snapshot and to take into account the dynamic of progress linked to Europe's ambitions in terms of decarbonisation (with the short timeframe of the 2030 Fit for 55), which will automatically result in a reduction in emissions linked to the electricity system and, moreover, to the road transport system (with undoubtedly longer timescales in the latter case for significant progress to be made). On their own, these developments will not be sufficient to represent game changers and this does not, of course, absolve the players in the payment system from making efforts in their own areas.

In summary: Worldline's commissioned LCAs go beyond the traditional focus on the cash cycle, introducing a higher level of complexity that requires discussion of the scope and limitations of the results. Analysing entire payment systems, instead of just product life cycles, leads to approximations of certain data due to unavailability in the Belgian context. Another set of limitations arises from the unique characteristics of the Belgian context, which exhibits heterogeneity in payment preferences compared to the broader euro zone. It is crucial to view these results as a snapshot and consider the dynamic progress in Europe's decarbonisation ambitions. The short timeframe of the "2030 Fit for 55" will likely reduce emissions linked to the electricity and road transport systems.

3. Targeting payments of 1g CO_2: nature of the objective and potential levers to be activated.

The conclusions of the LCAs allow us to measure (for cash or card transactions in shop, or online) the gap for reducing the carbon footprint of these transactions, of which the order of magnitude is 2 to 3 g. Closing this gap will not be without its challenges, particularly in terms of coordination within a complex ecosystem.

Admittedly, such an objective has a symbolic character insofar as, as we have indicated, the data derived from LCAs must be considered with hindsight, anchored in the Belgian context, and based on an "average" consumer who – by construction – does not represent the socio-economic diversity of the uses of means of payment.

However, given that the EU's Fit for 55 will require decarbonisation efforts between now and 2030 on the same scale as those made ... since 1990, it seems to us that this breakthrough in the area of payments is consistent of the acceleration that needs to be achieved. And that, as a result, identifying the levers that can be activated is useful in view of the urgency of the situation.

What's more, introducing low-carbon payments to the public, and making them known, is essential given the frequency of payment transactions. This could give players in the payments ecosystem a credibility that would also enable them to inform consumers of the environmental impact of their spending, with indirect but probably not negligible effects. In addition to reducing the direct environmental impact of payment systems, numerous innovations in this field can have a knock-on effect, particularly through the virtuous uses of blockchain.

3.1. Why aim for a 1g $eqCO_2$ transaction? And what leverage effects have LCAs identified?

Under what conditions is it possible to approach transactions at 1g $eqCO_2$ per unit? The life cycle assessments commissioned by Worldline identify the gaps to be filled, the levers activated to this end, and the conditions for success.

To underline what is at stake, we can first consider the following calculation:

- The LCA for online payments shows a footprint per payment of around 2.5g eq CO_2, or around 3,500 tonnes of CO_2 for all the transactions managed by Worldline.
- Reducing this footprint to 1g, all other things being equal, would reduce the tonnes of CO_2 emitted to 1400 tonnes, thus avoiding the emission of 2100 tonnes/year.
- Of course, this does not take into account the variety of other positive effects (abiotic resources, air pollution, water use, etc.).

Let's proceed here by considering each of the 3 payment methods taken into account in these LCAs.

i) Cash transactions:

- The LCA indicates that the impact of a single ATM withdrawal transaction is the source of around 20g $eqCO_2$, 80% of which is due to the impact of the ATM.
- By multiplying the number of payments from the same initial withdrawal, this footprint becomes smaller than that of payment by card, from around 8, while 20 transactions are needed to move towards a 1g transaction.
- In the short term, marginal gains can be made by refusing the payment ticket (0.33g) and in the medium term by reducing the footprint associated with banknote production...
- ... but, fundamentally, the leverage effect can only be applied to the footprint specific to ATMs.
- What's more, the LCA did not include the footprint of transport to the ATM. Bearing in mind that a kilometer travelled by car emits around 100g of CO_2, a withdrawal made by this means of transport has a footprint that makes it impossible to achieve the target of 1g per transaction[17].
- Finally, and most importantly, as the reduction in the footprint is conditional on an increase in the number of transactions, these conditions of use are considerably restrictive, and much more limited than for in-store card purchases.

17 See more detailed calculations in the appendix.

All in all: achieving a 1g transaction in cash payments is out of reach. The footprint can, however, be limited by consumers in the short term (withdrawing cash using low-carbon transport, use cash for small payments, refusing to print the ticket).

ii) In-store card transactions:

- The LCA indicates that an in-store transaction generates around 2.45g eqCO_2.
- Since ticket printing accounts for 42% of the total, eliminating it reduces the transaction to 1.42g eqCO_2.
- Paying by smartphone has no impact if this equipment is accounted for at its average cost, but if the marginal cost is taken into account, 0.44g eqCO_2 are also saved, bringing the transaction down to around 1g.
- However, this approach raises two objections:
  - Such a gain is conditional on the total abolition of the bankcard, which is plausible in the long term, but is not yet common practice (insofar as the smartphone is not a substitute for the bankcard for all its uses).
  - Accounting for smartphones at marginal cost seems coherent to us, since this equipment is multifunctional and its acquisition is not specifically triggered by the need to make payments via it. However, average cost accounting is the norm in LCAs.
  - The other lever, as long as the network part weighs little, is to reduce the footprint of the payment terminal (which accounts for around 0.5 g). In the short term, extending the lifespan of terminals means that this footprint can be reduced, as can technical progress with new equipment in the medium term. A saving of 0.25g through one or other of these two levers seems plausible.

All in all, convergence towards in-store payment at 1g eqCO_2 is a plausible prospect. In the short term, this will depend on the abandonment of tickets, which will rapidly have a massive effect (-42%). In the longer term, abandoning the production of bankcards (or at least making them optional) will allow transactions to be carried out using smartphones. This, combined with more efficient terminals (or terminals that are used more sustainably), will bring us very close to the target of 1g eqCO_2 per transaction.

iii) Online transactions:

- The LCA indicates that an online transaction generates 11.9g eqCO_2.
- Since the authentication device accounts for 75% of this footprint, its elimination would lead to a performance close to 3 g eqCO_2.
- Since the smartphone, accounted for at average cost, represents 15%, its inclusion at marginal cost reduces the transaction to around 1.2g eqCO_2.
- The eventual abolition of bankcards, in the long term, would also result in an additional reduction of 0.8g eq CO_2, reducing the transaction to significantly less than 1g (0.4g).

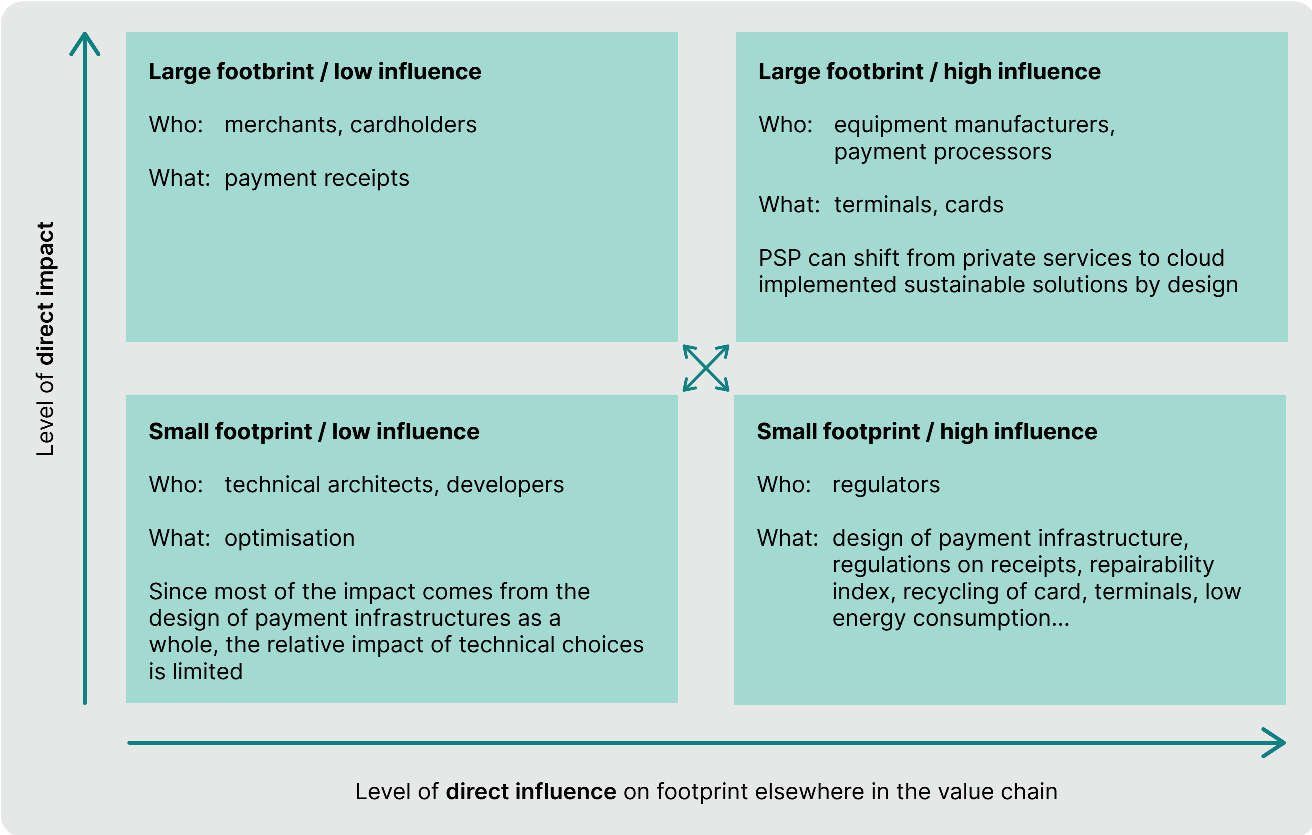
All in all, simplified online transactions with the elimination of authentication boxes in the short term and, in the longer term, the provision of a bankcard only as an option, making it possible to envisage transactions of less than 1 g.

Thus, we can see that to effectively reduce the digital footprint of payments, an end-to-end life cycle assessment is necessary. By providing visibility, a number of levers can be activated to reduce the CO_2 emissions associated with payment transactions by mobilising payment stakeholders: regulators, merchants, banks, card companies, etc. However, as a counterpoint to this observation, it is important to stress that, given the complexity of the payments ecosystem, optimising certain elements of the value chain in isolation is ineffective.

Convergence towards 1g payments therefore would require collaboration between all the stakeholders: the operational payment players (merchants, device manufacturers, payment service providers, systems and standardisation bodies), the public authorities responsible for drawing up regulations (on payments, but also on the environment) and those responsible for supervising payment activities.

Not forgetting consumers, whether households or businesses, as we shall see below.

Figure 11. Impact/influence matrix – Environmental footprint of digital payment players.



Source: Worldline, Navigating Digital Payments: Reshaping customer experience by simplifying complexity, 2021.

In summary: The life cycle assessments commissioned by Worldline identify the possibilities of achieving transactions at 1g CO_2e per unit for different payment methods. Except for cash payments, this objective seems plausible for the other payment methods included in the analysis, provided, in particular, that the printing of tickets is eliminated in the short term, and in the longer term that the provision of a bankcard is made optional (using a smartphone for the same functions). To get an idea of what is at stake, consider that the switch from 2.45g to 1g for digital transactions managed by Worldline in Belgium would avoid the emission of 2,100 tonnes of CO_2 per year.

3.2. Over and above this, payment services can encourage climate-friendly consumer behaviour.

But the debate on the environmental effects of digital technology is highly complex and cannot be confined to measuring the direct carbon footprint of systems (or other related parameters linked to the extraction of raw materials, water consumption, etc.), without also taking into account the way in which these technologies can contribute to the transformation of socio-economic organisations.

This is all the more necessary as the health crisis has accelerated the use of 'remote' activities (online commerce, but also teleworking, distance learning, telemedicine, etc.) made possible by the high level of household and business equipment and the increase in broadband connections (at least in the most advanced economies), but also by the availability of means of payment adapted to these changes in social lifestyles (Geoffron, 2023).

It is therefore important that, in addition to efforts to move towards reduced-impact transactions (and, as much as possible, converge towards 1g per unit), electronic payment methods can also be a lever for encouraging sustainable consumption choices. By integrating functionalities such as reward schemes for eco-responsible purchases or the possibility of giving consumers information on the carbon footprint of their purchases, the payments ecosystem can encourage users to opt for more environmentally-friendly products and services or behaviours. While it is beyond the scope of the present document to provide an exhaustive list of the avenues that are consistent with these guidelines, a few illustrations may help to gauge the value of mobilising the payment ecosystem to activate and leverage these impacts.

Firstly, digital payments can contain information about the carbon footprint of purchasing actions, via the electronic payment data that circulates between consumers, banks, payment service providers and suppliers of goods or services. The concept of 'carbon labelling' is inspired by the widely used food labelling, which informs consumers about the calorie content of food. This approach is based on an obvious fact: it will not be possible to introduce changes on the scale of the Fit for 55 ambitions, over a period as short as the end of the current decade, without greater transparency on the carbon content of current consumption.

A number of projects have illustrated the implementation of such a labelling process using data from a major British bank (Trendl et al., 2022; Barrett et al., 2023):

- The aim was to determine the amount of carbon produced per £1 spent on a good or service, based on the financial transactions of an anonymous population (around 3 million individual customers and 800,000 businesses).
- The analysis shows that emissions measured in this way through digital payments are highly concentrated in a limited number of payment types. 15 digital payments cover almost 60% of all emissions: direct debits for gas and electricity, card payments for petrol, gas, plane tickets, etc.
- Researchers have compiled 'carbon multipliers' so as to attribute a footprint to purchasing actions: for example, a pound spent on fuel has a carbon multiplier close to three, which means that 3 kg of carbon are generated for each pound spent on fuel (Kilian, 2022).
- For businesses, this information could simplify the calculation of carbon intensities in supply chains and guide commercial strategies. For consumers, it would enable them to make informed choices, possibly combined with incentives offered by suppliers and/or public authorities. The latter would benefit greatly, as emissions could then be measured more consistently, opening the way to potential innovative policies.

By way of illustration, we can also look at some of the developments arising from the uses of blockchain. While this family of technologies is often viewed from the angle of the power consumption of certain validation protocols (as mentioned above), uses that favour environmental objectives now abound. For a panoramic view of this field, reference can be made to Blockchain for Good (2022), which has gathered information on some 700 blockchain projects, each of which is linked to the pursuit of one or more of the Sustainable Development Goals. Blockchain initiatives in the environment and climate aim to decentralise voluntary carbon markets, water markets, waste collection financing and donations for environmental projects (agroecology, reforestation, etc.). Blockchains have a vast potential in the energy sector, whether in the areas of energy trading, energy certification or network optimisation.

Furthermore, aware of the environmental and ecological issues they raise, some blockchain players are working to decarbonise the sector. This is the stated aim of the Crypto Climate Accord, initiated in 2021 by Energy Web, the Rocky Mountain Institute and Alliance for Innovative Regulation (since joined by more than 250 market players). The shared ambition is to decarbonise the global crypto-currency sector by supporting the transition to zero net greenhouse gas emissions by 2040 and, in the meantime, achieving zero net electricity emissions by 2030 and developing standards to accelerate the adoption and verification of progress towards blockchains powered 100% by renewable energy (this ahead of the COP30 in 2025).

Box 4. How payment technology can help make travel more sustainable.

Worldwide, 40% of travellers say they are prepared to pay at least 2% more for carbon-neutral tickets, but only 14% have already done so. How can payment technologies help reduce the gap?

1. **Promoting greener aviation:** Payment technologies can help promote more sustainable aviation by rewarding customers who make greener choices. Airlines are striving to use alternative fuels to reduce their carbon footprint, with the aim of enabling the sector to reach its target of zero net emissions by 2050. Some airlines are using reward cards to encourage travellers to make sustainable choices. Etihad Airways, for example, has launched its "Conscious Choices by Etihad" programme, under which members earn rewards by carrying less luggage and donating miles to approved organisations.
2. **Encouraging people to use public transport:** A recent survey found that 88% of respondents said sustainability was a key factor in how often they travelled by public transport, and 34% said it was the main reason they used public transport. Contactless payments in public transport systems can also reduce emissions, as buses and trains idle less when people are not looking for money or trying to work out the fare. A study in Toronto found that buses idled less when passengers used keypads to pay instead of cash.
3. **Making travellers more aware of their impact:** Innovative partnerships in the payments sector are beginning to help make travellers more aware of the environmental impact of their journeys. The Visa Ecobenefits Bundle, for example, enables banks and issuers to add sustainability features to consumer cards. One of the key features, supported by ecolytiq's sustainability-as-a-service platform, allows cardholders to estimate the carbon impact of their spending.

Source: World Economic Forum, 3 ways payment technology can help make travel more sustainable, 2022.

In summary: The debate on the environmental effects of digital technology is complex and goes beyond simply measuring the direct carbon footprint. It is also about examining how these technologies can transform socio-economic organisations, and how payment services can play a role in promoting environmentally-friendly consumer behaviour. For example, they can incorporate features such as reward systems for eco-responsible purchases and provide information on the carbon footprint of purchases. Blockchain technology also offers potential for sustainable development efforts. Many blockchain projects are aligned with sustainable development goals and aim to decentralise carbon markets, water markets and the financing of environmental projects such as agroecology and reforestation.

Conclusion: main contributions of the LCAs & how to build on them.

The aim of this paper was to provide a panoramic analysis of the issue of decarbonisation of payment systems, in the context of their accelerated digitisation, and to assess the scope of the original LCAs commissioned by Worldline.

All things considered, taking the standard cash transaction as a reference, the in-store electronic transaction allows for a -16% reduction of CO_2 emissions. Furthermore, when optimising the electronic payment transaction, we observe various levels of CO_2 emissions reduction (compared to a cash transaction).

- First of all, removing the receipt from an in-store electronic transaction results in a -53% reduction in CO_2 emissions.
- Secondly, in addition to removing the receipt, eliminating the physical credit card also leads to a -64% reduction in CO_2 emissions.
- Finally, CO_2 emissions are reduced by a factor of 4 (-73% reduction) with a complete optimisation of the in-store transaction, including phone-to-phone payments.

With these numerical results in mind, this led to a discussion on the objective of organising payment transactions that do not exceed 1g of CO_2 equivalent per unit. As we have indicated, this objective may appear to have primarily "symbolic" value. But by reducing, for example, digital payments in shops (representing around 2.5g), it corresponds to a break of an order of magnitude that is consistent in Europe with the Fit for 55 ambition. And, as already pointed out, at the level of Belgium and for the transactions operated by Worldline, the annual volume of CO_2 avoided would be 2,100 tonnes. Extrapolated, on the same basis, to all the European transactions managed by Worldline, this annual volume would be closed to 28,000 tonnes, contributing to the objectives of the TRUST 2025 plan[18].

From this perspective, the merit of the LCAs produced under the aegis of Worldline is to improve the "state of the art" through a comparative approach. With hindsight, the key messages that can be drawn from them are as follows:

i) **These LCAs highlight the fact that the use of cash (from ATMs) has a considerably higher carbon footprint than that of the other methods included in the scope analysed, and this is largely irreducible** (despite the efforts made by central banks to reduce the specific footprint relating to the banknote cycle). Of course, the expectations of European citizens in terms of the diversity of means of payment, socio-economic inequalities regarding the use of cash, and privacy concerns mean that a wide choice must be maintained (ECB 2022). Nevertheless, it is essential, at a time when carbon accounting must be imposed in all areas, to be aware of this "hidden cost" of operating the cash circuit. And, consequently, of the advantage of the most advanced countries in terms of reducing the use of cash.

ii) **While there are some 'low hanging fruits'** in reducing the footprint of the various payment methods analysed (limiting small cash withdrawals, not printing payment receipts, not using an authentication device, etc.), the most significant improvements will come from a future where simplified transactions using everyday digital objects (smartphones, connected watches, etc.) will have replaced bankcards (via the Internet of Things, too). The challenge is not only to avoid the environmental footprint associated with bankcards (and their combination of plastic and electronic chip content), but also to make payment transactions more fluid (with positive effects on public transport operations, for example). These gains in fluidity (in terms of carbon, but also of time) undoubtedly deserve more attention: their benefits are already visible in the free flow at motorway toll booths, for example.

iii) **Furthermore, improving overall performance means combining the efforts of each player in the payment chain:**

- Banks need to extend the life of cards and terminals and include them in a circular economy approach at the end of their life; In addition, the trust they have established with their customers can give them an advantage in their ability to inform them about the footprint of their payments, and about good practices in this area. More specifically Belgian banks need to stop using an authentication device to authenticate cardholder in an eCommerce transaction. Looking further ahead, banks should be moving away from cards and payment terminals;
- Merchants need to convince customers to dispense with tickets; as things currently stand, the former have no specific interest in it, which is problematic, and this ticket impression weighs heavily on the overall footprint of the process. It is essential that public policy gradually restricts the use of tickets; Belgian merchants need to avoid printing the receipt, since their system is online.
- Legal regulator need to make it possible not to print the cardholder and merchant receipts; it can also influence the merchant not to print the receipts;
- Payment providers need to optimise their systems to ensure the lowest CO_2 footprint;

18 Given that, in 2022, Worldline processed 27.7 billion transactions and using Belgian data for illustrative purposes only.

- Terminal manufacturers need to ensure that they optimise their energy consumption in active and standby modes and do not “outbid” them (the trend towards tablet-type screens is counterproductive in this respect), transaction processors need to store the minimum amount of data, extend the life of IT equipment and dynamically adapt the sise of processing platforms to the volume of transactions;
- Consumers must do their bit by agreeing to do without a ticket, by limiting the number of cash withdrawals without fragmenting them into small samples, ... Such a development will obviously take time, and will require better information on their part, a shared responsibility between the public authorities and the players in the payment ecosystem.

The difficulty lies in coordinating these efforts. The players in the European Digital Payments Industry Alliance have a specific role to play and need to be proactive, interacting with the public authorities[19].

iv) **But the key issue, beyond these efforts, is undoubtedly the ability of payment systems players to contribute to collective efforts to reduce carbon emissions.** Payment transactions are a particularly suitable space that can be used to inform consumers about the carbon footprint of their consumption patterns, but also to encourage them to make efforts and even reward them for it (current experiences in air transport illustrate this orientation). In addition, a number of experiments involving the virtuous use of crypto-currencies suggest that there is potential for accelerating the development of renewable energies, facilitating electric mobility, enabling voluntary carbon markets to emerge, among other perspectives.

In other words, players in the payment ecosystem must not only decarbonise their systems and make this known to their consumers, but also (and above all, no doubt) enable the deployment of more fluid and information-enriched solutions for their users concerning the footprint of their consumption. Clearly, this is where the greatest contribution to decarbonisation will be made.

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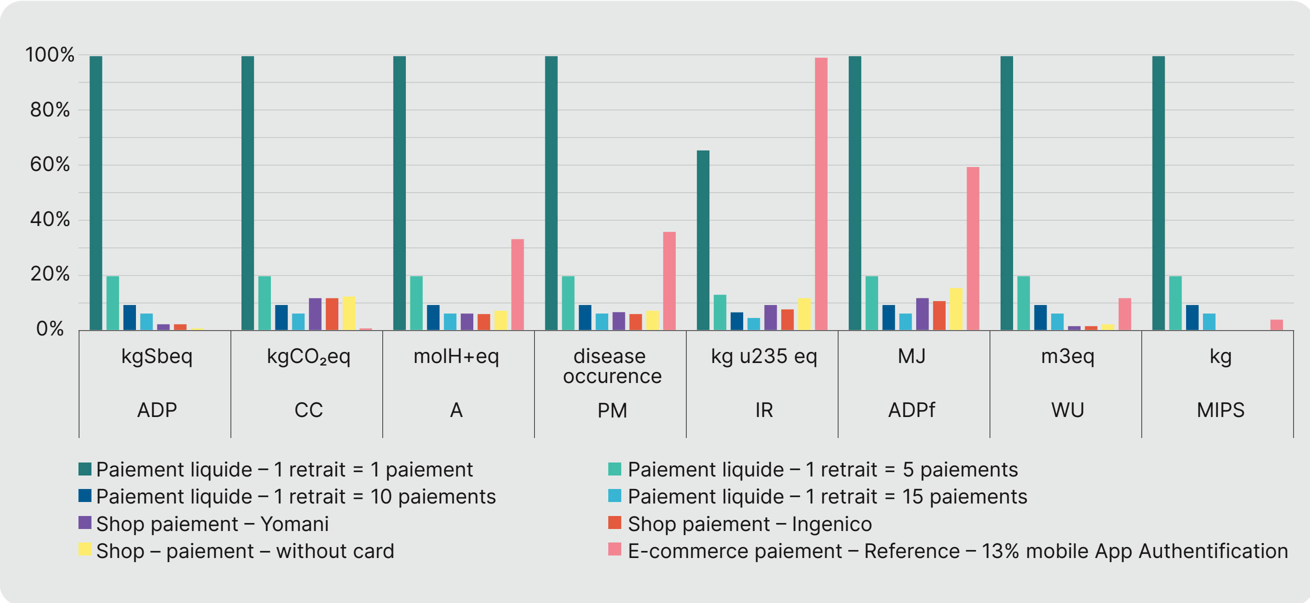
Appendices.

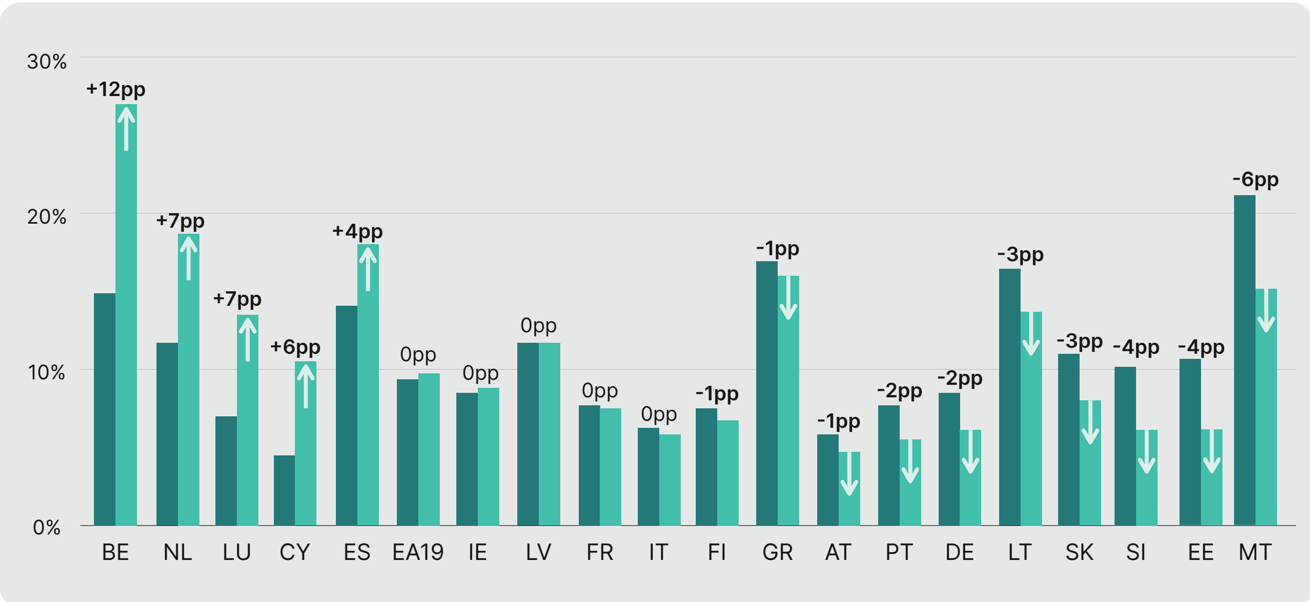
Figure 12. Comparison of the 3 payment methods according to their carbon footprint and the number of transactions carried out.



Source: DDemain & Solinnen, Analyse du Cycle de Vie d'une transaction financière effectuée par argent liquide, Étude commanditée par Worldline, 2022.

Legend: ADPe – Abiotic Depletion Potential element; CC – Climate Change; A – Acidification, PM – Particulates matter; IR - Ionising radiations; ADPf – Abiotic Depletion Potential fossil; WU – Water use; MIPS – Material input per services unit.

Figure 13. Share of respondents perceiving access to cash withdrawals to be fairly or very difficult, by country (2019-2022).



Source: European Central Bank, Study on the payment attitudes of consumers in the euro area, SPACE 2022.

Figure 14. Evaluation of the impact of a cash withdrawal at an ATM in terms of the transport footprint.

Here we have calculated the carbon footprint associated with transport to the ATM, based on assumptions about the distance to the ATM and the means of transport used and its specific footprint.

We have remained within the framework of the LCA dedicated to cash by making the assumption that the withdrawal is fragmented into 7 payments. The conclusion is that, under these assumptions, the carbon footprint of transport to the cash dispenser is 238g eqCO_2, or 34g per payment made.

This is obviously just an illustrative exercise, since transport to an ATM may be combined, for example, with shopping in a shopping centre (in which case the transport footprint would have to be shared). But whatever the case, this calculation makes it possible to give a "materiality" back to an essential stage in the cash chain.

Furthermore, to get the full picture, we would also need to add the transport footprint at the stage of cash management by the retailer, which would logically increase this footprint still further.

Hypotheses:

- In Belgium, 82% of people have an ATM less than 2km far from home. Source multimedia.lecho.be/distributeurs-de-billets
- The transport means split in Belgium is as follows. Source news.belgium.be/sites/default/files/news-items/attachments/2019-12/2019_Monitor_FINAL_FR.pdf)
- The CO_2 emissions per means are avenirclimatique.org/calculer-empreinte-carbone-trajet

Mode	%	g CO_2 2km	Weighed	per Transaction /7
Car (Fossil)	61	380	232	33
Walk	14	0	0	0
Bicycle	12	0	0	0
Train, subway, tramway or bus	11	59	7	1
TOTAL		**439**	**238**	**34**

Table of illustrations.

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Patrice holds a doctorate in industrial economics and is a professor at Université Paris-Dauphine-PSL, where he was interim president and international vice-president. He was also the founding director of the Dauphine Economics Laboratory (LEDa).

His early work led him to analyse the dynamics of venture capital in the United States and the organisation of the industrial model in Japan. For the past fifteen years, he has specialised in evaluating investments in environmental transition and its new business models (sustainable IT, smart grids, smart cities, low-carbon mobility, etc.), in particular through certain uses of blockchain (he is involved in the "Blockchain for Good" research initiative).

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About Worldline

Worldline [Euronext: WLN] is a global leader in the payments industry and the technology partner of choice for merchants, banks and acquirers. Powered by c. 18,000 employees in more than 40 countries, Worldline provides its clients with sustainable, trusted and innovative solutions fostering their growth. Services offered by Worldline include in-store and online commercial acquiring, highly secure payment transaction processing and numerous digital services. In 2022 Worldline generated a revenue close to 4.4 billion euros.

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