EUROPEAN CENTRAL BANK

EUROSYSTEM

A big future for small payments? Micropayments and their impact on the payment ecosystem

1 Introduction

The concept of micropayments has been around since at least 1960, but interest began to take off in the early 1990s with the growing use of the internet. Although almost all micropayment solutions released into the real world have failed to achieve widespread adoption, the idea is now attracting renewed attention from the retail payment industry – mainly owing to digitalisation, which calls for new ways to make payments. Consumers are increasingly facing situations in which efficient micropayment solutions could ease their online purchases, particularly as demand for online content grows. However, as such solutions are not yet in place, the opportunities that micropayments could offer are largely being missed.

Not all traditional means of payment are suitable for micropayments owing to processing costs and subsequent pricing levels. Consequently, some academics and technology experts conclude that new systems and solutions will need to be developed in order to minimise transaction costs and provide a seamless end-user experience. In parallel, the payment industry has started looking into ways to optimise micropayments in order for them to become standard practice in terms of transactions for the general public.

The latest technologies and emerging business models are focused on making financial products available to consumers at a negligible price. Distributed ledger technology (DLT) is portrayed by some as an infrastructure that could potentially bring down transaction costs by cutting out the intermediaries that are present in legacy payment systems. Machine-to-machine (M2M) automated payments, which allow internet of things (IoT) devices to interact and communicate autonomously, are emerging as likely candidates to make a significant impact on the payment industry of the future. The IoT market has grown exponentially over the past few years and M2M solutions could be seen as the next potential revolution in the area of payments.

This paper aims to provide a comprehensive analysis of micropayments in terms of the relevant challenges and opportunities, setting out all the ingredients for a forward-looking assessment of their potential future role in the digital economy. The analysis presented here has been informed by discussions with market stakeholders dealing with micropayments in the European payment market.[1]

[1] On 6 December 2022 the ECB had an exchange on the topic of micropayments with representatives of six European market stakeholders and 15 members of the European System of Central Banks. That dialogue covered the potential impact of micropayments on the payment landscape, innovation trends relevant to micropayments, economic viability, and social aspects of micropayments.

2 Characterisation of micropayments

There is currently no agreement on how micropayments should be defined. The term is commonly understood to refer to payments of very low value, which are usually made online. However, the precise threshold ranges from a few euro to a few cents – or even fractions of a cent – depending on the target market and the efficiency of the payment systems in which they are processed.

For example, while PayPal defines micropayments as payments with a value below €5, the consultancy Innopay defines them as payments of less than €1 and Investopedia defines them as payments of less than USD 1.[2] Meanwhile, the Oxford Dictionary of the Internet does not specify an upper limit, instead defining micropayments as monetary transactions that are too small to process economically using conventional means of payment.[3]

Based on the Oxford definition, economic feasibility is intrinsically linked to the cost of conventional means of payment. In this respect, micropayments could be defined as payments that are economically unviable owing to their costs and have no viable business models in terms of payment solutions that deliver transactional value to their users. With this in mind, the most practical way to evaluate economic feasibility and identify the approximate point at which payments start to generate transactional benefits is to consider the underlying costs of legacy payment instruments.

Individual payment instruments have different costs, so they vary in terms of their suitability for low-value payments. The European Central Bank paper "Costs of retail payments – an overview of recent national studies in Europe", which gives an overview of studies on the social and private costs of retail payments conducted since 2013 in nine EU countries, shows that all legacy electronic payment instruments generate costs that may generally constrain the use of payments below the value of €1. More concretely, when payments of less than €1 are conducted using legacy payment instruments, the costs seem to outweigh the benefits.

Based on this, and against the background of the existing divergence of views, a micropayment is defined, for the purposes of this paper, as **an online, mobile or machine-initiated transfer of funds with a value of close to or below €1 for the purchase of digital goods and services with immediate or almost immediate delivery.** However, it should be noted that the boundary between micropayments and other payments is not always clear-cut, since higher costs may be incurred in certain situations.

The proposed definition may not necessarily coincide with the approach adopted by other authors. At the same time, the definition is intended to be future-oriented, mainly taking into consideration the emergence of the machine economy.

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2 In Europe, PayPal defines micropayments as payments between €0.01 and €5; in the United States, it defines them as payments with a value below USD 10; in the United Kingdom, it defines them as payments of less than £5.

3 The Oxford Dictionary of the Internet defines a micropayment as "a monetary transaction that is so small that it is not economically feasible to process it using conventional means such as bank clearing".

3 The emergence of micropayments

The term “micropayment” was coined by the technology futurist Theodor Holm Nelson back in the 1960s while working on his idea for a computer network which would serve as a repository of all human documents. That would result in a global electronic publishing system, in which users would be able to use links (i.e. hypertext) to navigate between documents available online and cite the authors. As part of this concept, he envisaged a micropayment system with low transaction costs for compensating copyright holders. Some 60 years on, Nelson’s idea has yet to become a reality and micropayments have yet to take off.

Deeper exploration of micropayment solutions and their possible deployment in practice started 30 years after Nelson’s pioneering idea, resulting in two main waves of micropayment solutions (Böhle, 2002).[4] In an attempt to introduce an electronic form of cash that could be used to purchase online content, pay for low-value network services and make transfers between individuals (e.g. to send money for lunch) the first wave of micropayment systems emerged in the early 1990s. These were mainly simple token-based micropayment solutions involving a third party (called a broker) that issued a vendor-specific electronic currency. One of the first generation of micropayment systems was Millicent. Developed in 1995, Millicent was promoted as the first microcommerce system that could enable information on the internet to be bought and sold profitably down to fractions of a cent. In the case of Millicent, a broker mediated between vendors and customers and issued a vendor-specific digital currency called “scrip”. Customers used “scrips’’ for payments by transferring these to specific vendors. Other notable token-based micropayment systems in the first generation included PayWord, MicroMint and eCash.

At the same time, other companies started developing account-based micropayment systems such as CyberCoin or Mondex, which had wallets on both the customer side and the merchant side and allowed payments to be made without involving banks. All of these systems eventually ceased to exist, mainly owing to the inconvenience of using them. Their cumbersome interfaces and the fact that wallets were linked to the computers on which they were installed (thus not allowing for portability) were huge drawbacks for users. This and other issues such as a lack of anonymity and interoperability (which was mainly due to the decision to create specific tokens, which could only be spent via one system, with no ability to convert or exchange them in other systems) prevented them from being adopted more widely.

Those pioneering micropayment systems eventually ceased to exist, clearing the way for the more advanced second generation that emerged in the early 2000s. These later systems were mainly account-based and more user-friendly, with increased scalability, enhanced user interfaces and anonymity for customers vis-à-vis merchants. There was the pre-paid BitPass and the post-paid Peppercoin in the United States, and there were Minitix, Micromoney and Way2Pay in Europe. Coverage improved with these solutions, as customers changed their behaviour, showing more willingness to pay for low-value internet-related content and activity

[4] See Böhle, Knud (2002), ‘’The innovation dynamics of internet payment systems development”, Report Nr. 63, Institute for Prospective Technological Studies.

(such as software downloads and database searches). While the majority of those second-generation micropayment systems are not operational anymore, PayPal (which was founded in 1998 to support online micropayments) has developed into a leading payment service offering payments worldwide. Major payment card operators and financial institutions also entered the micropayment market, albeit with little success. Mondex and Visa Cash – electronic payment systems operated by Mastercard and Visa respectively – aimed to provide an alternative to cash payments, especially for micropayments, but were disappointing.

While micropayments were already being used for online media consumption and gaming back in the 1990s, they have never really developed to the point of allowing widespread usage.

4 Current and potential future business cases for micropayments

Many conventional services now have online versions, and with increasing numbers of services and solutions available online, a new market is emerging, revolving around the exchange of low-value payments. Today, the market for micropayments stems from demand for online services such as streaming media, online publishing, applications and gaming.

4.1 Micropayments for online goods and services

Four different types of arrangement are used to make micropayments online, but all have their own deficiencies, thus preventing wider adoption. The first of those, pay-as-you-go, enables users to pay immediately for purchases using – typically – e-money, payment cards or mobile SMS.[5] While this model is the most appealing for users, as they only pay for the service or content they consume, it does not really work in practice. The amount of transaction costs that are incurred every time a micropayment is processed is restricting take-up of this model.

To avoid transaction costs while still covering very small amounts, pre-pay and post-pay business models were introduced. Pre-pay is used for advance payments, allowing users to access the service (newspapers, games, etc.) for a defined period of time. It is often in the form of a subscription fee, which users may regard as a disadvantage, as they need to pay a lump sum up front for services which may not be relevant for them and most users do not want to feel trapped by long-term financial commitments. In contrast, the post-pay model aggregates sums due over a certain period of time and sends a bill for one amount (instead of conducting numerous individual transactions).

The fact that the pre-pay and post-pay models usually require the existence of an account imposes an additional step in the payment process and is often perceived as burdensome and inconvenient by payers. Users require simple and efficient

[5] The company MPulse has a one-off SMS payment solution that allows customers to pay for digital products and services via a single SMS (i.e. via a mobile subscription).

means of initiating online payments. One example of a convenient means of payment is the contactless cards used in physical shops, which allow users to just tap the terminal. Any additional steps, such as creating an account or providing personal data, are discouraging. In addition, post-pay payment solutions come at a risk for merchants, as the outstanding amount may not necessarily be paid by the buyer.

The fourth and most viable option is the collaborative model, whereby different sites are connected, allowing different publishing platforms to work collectively. This is especially beneficial for smaller online publishers with smaller numbers of users, which may not otherwise be able to support a profitable system for micropayments. This model is advantageous, given that it allows numerous online publishing businesses to make extra financial gain on written content.

Micropayments allow merchants to adapt to new business models and allow consumers to benefit from content produced by a variety of sources without a long-term commitment. Indeed, there are three main business models where micropayments could be of relevance: resource on demand, content on demand and service on demand.

4.1.1 Resource on demand

Resource on demand is a model where, instead of paying in bulk or in the form of a monthly or yearly subscription, users are charged on the basis of their actual consumption. A typical example is the internet service offered in public places like airports, where users have to pay large amounts for WiFi hotspot access even though they are only using the service for a few seconds to download a few emails and send messages to family and friends. Paying for a resource in bulk provides value to businesses by allowing them to avoid unprofitable transactions amounting to a few cents. However, from a consumption perspective, a pricing model that reflects users' actual consumption may prevent them from overspending by allowing them to pay for metered use of a service.

Box 1
Micropayments for WiFi access

Boingo provides mobile internet access for wireless-enabled consumer devices in airports, hotels and public areas all over the world. It uses the pay-as-you-go pricing model, charging between USD 0.12 and USD 0.18 per minute, and allows consumers to pay for their actual use of the service, rather than paying a monthly or yearly subscription fee.

4.1.2 Content on demand

Content on demand is a service that enables users to purchase only the specific piece of content which they are interested in. In practice, this allows users to buy a particular song, video or article instead of a whole album or magazine. Today, providers have different approaches towards monetising their online content. The most common method is a paywall, allowing users to select and access a certain segment of the content while restricting access to the rest. As a result, users need to choose between (i) paying a large fee for a monthly or annual subscription and (ii) paying nothing and looking for the desired content elsewhere. This binary model is inadequate and creates information asymmetries, so increasing numbers of companies are looking at ways to offer micropayment solutions to publishers.

Box 2

Micropayments for online media

The Dutch-owned company Blendle provides a platform for aggregating articles from different newspapers, with fees deducted from a Blendle wallet (which can be topped up using a credit card or a PayPal payment). Initially, the firm's model allowed users to buy one article at a time for a small fee, rather than offering subscription options. The prices varied from €0.09 for snippets to €1.99 for whole stories, with users paying around €0.35 per article on average. Although this initiative appeared promising for the newspaper industry, Blendle announced in 2019 that sales of individual articles would be replaced by a premium subscription service, as the micropayment model had proved to be unprofitable.

Video is another example of a content on demand service where micropayments could be useful. Small amounts of money could be paid to their creators, thus replacing the need for advertisements. In March 2019, the American National Basketball Association (NBA) launched a micropayment-based livestreaming service in which viewers can watch ten minutes of live action for USD 0.99 instead of paying a monthly subscription. As micropayments do not commit customers to a contract, the NBA is aiming to address the personalised needs of users – particularly millennials, who are keen to only spend money on content they care about. Users who are already paying subscription fees to other entertainment media sites (TV, Netflix, Spotify, etc.) are more willing to pay a one-off fee for a game (or part of a game) than another monthly subscription fee.

4.1.3 Service on demand

A service on demand model allows users to make micropayments to other users in return for low-value services or tasks. These are situations where one person would like a response (e.g. a reply in the form of a message via email, LinkedIn, etc.) from another and is willing to pay a small amount of money for it.

Box 3
Micropayments for email responses

The company Earn allows individuals to pay recipients small amounts for replying to their emails in order to increase their chances of receiving a response. This also allows senders of commercial emails and surveys to get quick replies to important messages. According to Earn, 30-70% of senders receive responses within one day in return for payments ranging from USD 1 to USD 10, compared with a response rate of 1.7% for regular messages.

4.2 Micropayments in gaming

Digital in-app purchases in gaming allow players to buy virtual items such as lives, moves, upgrades or additional functionalities using micropayments. The exponential growth of mobile payments has boosted mobile gaming in recent years. Indeed, by the end of 2025 the global gaming market is predicted to have a total value of USD 256.97 billion, with USD 100 billion of that coming from mobile games. There are 3.2 billion gamers around the world.[6] This tremendous growth has made gaming a profitable industry, with players willing to spend lots of money on digital goods. As with online content, regular subscription fees do not seem to suit gamers, who feel more comfortable making regular micropayments. In addition, a considerable percentage of users may be young and lack sufficient access to conventional means of payment. This allows game developers to monetise free-to-play games.

Overall, when it comes to gaming purchases, players prefer seamless payments. Thus, PayPal is the preferred payment method for gaming platforms,[7] allowing low-value payments such as €0.99 for in-game purchases, followed by payment cards (mainly in the form of pre-paid cards) and global X-Pay methods (e.g. Google and Apple Pay).[8] Also, some games providers ask for advance payments, which are usually made using cards or direct debits.

4.3 Donations and tips

Transaction fees continue to be a problem for existing payment solutions when it comes to transferring small amounts. Thus, micropayments could be a way for fundraising organisations to increase charitable donations by reducing transaction costs and allowing more money to reach the places where it is most needed. Micropayments could also enable people with lower incomes to participate in charitable activities, making the world of fundraising more inclusive.

6 How Much Is the Gaming Industry Worth in 2023?.

7 What turns players into payers? Understanding the gaming payments experience.

8 In Germany, the most used payment method per gaming device is PayPal (70%), followed by Mastercard (11%) and pre-paid cards (10%).

Micropayments could also be used to tip service providers, or even to pay children pocket money in return for helping around the house.

4.4 The future of micropayments in the light of the internet of things

The increasing digitalisation of services offers new areas of opportunity. Payments are becoming even smaller, especially as far as IoT and M2M payments are concerned. **Incorporating micropayments into IoT could boost their potential.**

IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that have unique identifiers (UIDs) and the ability to transfer data over networks without requiring human-to-human or human-to-computer interaction. In this respect, IoT can be defined as a network made up of vast amounts of connected smart devices that have their own IP addresses. In the last few years, IoT has already been used in a number of different industries, mainly to share and collect data – usually through a central entity (i.e. in a centralised way). While IoT adoption is still in its infancy, the rise of cheaper and more reliable technologies (e.g. cloud computing) and demand from various industrial sectors are expected to fuel an increase in take-up. The IoT market size was valued at USD 544.38 billion in 2022 and is projected to grow from USD 662.21 billion in 2023 to USD 3,352.97 billion by 2030, with a compound annual growth rate of 26.1% during the forecast period.[9] Experts predict that up to 50 billion IoT devices will be connected by 2030 in place within the next years, which corresponds to around 6 devices per person on earth.[10]

IoT can be leveraged to provide customised payment services that meet the needs of consumers. Integrating micropayments into IoT by allowing devices to conduct payments autonomously without human intervention can help to build an M2M economy. In an M2M economy, devices will act as payment market participants, with each device having its own payment account. For example, a device could be powered or charged using a power socket and pay for its own (metered) use of electricity.

Currently, several factors related to IoT and micropayments are posing major challenges to the growth of an M2M economy. The high transaction costs for micropayments and the lack of any infrastructure that properly deals with the issue of the scalability and safety of such payments (ideally requiring payment-on-delivery for content or services) both need to be addressed in order for IoT to reach its full potential. In addition, IoT devices currently have specific limits in terms of power and storage. However, it is expected that IoT devices will evolve in the future, allowing for additional features such as micropayments and bringing value-added services to consumers. **With this in mind, there will be a need for new payment solutions that enable dozens of entities to transact directly with each other, either in response to commands or autonomously on the basis of predefined policies.**

9 Internet of Things (IoT) market size, share & COVID-19 impact analysis.

10 IoT in 2023 and beyond.

5 Requirements and challenges as regards the processing of micropayments

The processing of micropayments is subject to various issues and challenges linked to their characteristics. These issues, which represent obstacles for system developers, can be divided into three main categories: technological, economic and social.

5.1 Technological issues

There are various technological challenges and requirements that need to be addressed when processing micropayments. Some relate to the functioning of payment instruments in general and are not exclusive to micropayments.

5.1.1 Security of the underlying technology

Trust plays a crucial role in the adoption of a new payment instrument, as security failures in the underlying infrastructure can impact users' trust and hamper adoption. Thus, security must be guaranteed if a payment instrument is to thrive and be used widely. Given that micropayments usually take place in the e-commerce environment, where security threats abound owing to the constant opportunities for cyber-criminals, using cyber-resilience and end-point security to prevent fraud is key to ensuring the smooth functioning of any micropayment system and end-user solution. Like any other innovation, micropayment infrastructure could pose risks if it is not designed carefully, as it could expose users to fraud.

Consumer protection has been enhanced by strong customer authentication (SCA) standards, which make it easier and safer for consumers to pay for goods and services online. However, online payments of less than €30 are exempt from those SCA standards. While transactions below this threshold are considered low-value, authentication still needs to be requested when a cumulative value of €100 is reached or five payments of up to €30 are made. While this can help to ensure that micropayments remain convenient and seamless, it also runs the risk of forcing fraud down into the micropayment environment.

While individual micropayments are low in value, the total value can quickly add up when multiple payments are made. Consequently, the technology underlying a micropayment system/solution needs to be adequately secure in order to protect users.

5.1.2 Reliability, availability and ease of use

Like security, reliability is of considerable importance, so a micropayment system needs to have a high degree of operational reliability. Users need reliable and fast services that (i) are available around the clock, (ii) are easy to use (with no need to

download software or set up multiple accounts for different websites, for example) and (iii) enable a unified user experience. The ability to make payments 24/7 is considered a key factor given the circumstances in which such payments are typically made. Services such as gaming, media streaming and IoT need payment infrastructure to be available around the clock.

5.1.3 Scalability

Payment systems and end-user solutions need to achieve critical mass in order for acceptance levels among merchants and consumers to successfully take off and remain stable. Further increases in digitalisation and e-commerce could dramatically accelerate the growth of micropayments, presenting great challenges for payment systems in terms of scalability, as could large-scale adoption of IoT and a rise in autonomous P2P payments. Large volumes of micropayments will require state-of-the-art technology that is scalable and able to cope with such volumes while maintaining high-level services.

5.1.4 Interoperability

Interoperability refers to a set of arrangements that allow participants in different systems to conduct and settle payments between them while continuing to operate only in their own respective systems. In order to be competitive and efficient, a payment market needs to have a wide variety of interoperable payment systems and solutions. Lack of interoperability is one of the main reasons why most micropayment solutions have ceased to exist or have not been widely adopted. Interoperability is of the utmost importance in order to make it easy for consumers to access payment accounts and make micropayments in a convenient and seamless way. This will allow mass deployment of micropayments and enable economies of scale, thereby making payment services more efficient.

5.2 Economic issues

Economic issues stemming from the characteristics of micropayments can also make it difficult to achieve widespread adoption. Although not as important as technological challenges, issues pertaining to economics are often neglected. If they are not properly addressed, this can significantly impede the widespread adoption of micropayments.

5.2.1 Transaction costs

In order for a business model to be sustainable, the economic cost of executing transactions should be sufficiently low. However, in the context of payments, the real cost of a transaction is translated into fees incurred by the payer and the payee and

can differ depending on the payment instrument used and the payment service providers involved. Merchants (i.e. payees) incur different types of cost, such as fixed fees caused by their acceptance of individual payment instruments and/or variable fees based on the value of transactions. Consumers, on the other hand, usually pay fixed fees to their payment service provider as part of a package. Fees may be charged immediately when the consumer makes a payment (either as a flat fee or as a percentage of the transaction value), or they may be included in a customer's bank account package. As payment transactions become more complex, involving more stakeholders, higher transaction costs are likely to be incurred.

By definition, micropayments are very low in value and in order to maximise profit for providers, the cost of micropayment transactions needs to be much lower than the value of transactions. With this in mind, content and service providers may opt for pre-pay or post-pay models, rather than pay-as-you-go, as such models allow customers to pay the accumulated amount before or after consumption. By aggregating micropayments into one larger purchase, rather than charging for each individual transaction, transactions fees can be reduced.

However, an increase in micropayment volumes in the future will result in significant declines in unit costs, as the relatively high (fixed) costs of infrastructure development can be spread across an increasing number of transactions. As a result, the value at which the processing of micropayments becomes profitable should also decrease.

5.2.2 The value of transactions

One aspect to be considered when it comes to micropayments is how small these payments could be. Regardless of the economic sustainability of tiny transactions, the first question is whether it is possible to pay less than one cent using electronic means of payment. This is certainly impossible with cash, as set out in Article 11 of Council Regulation (EC) No 974/98 of 3 May 1998 on the introduction of the euro, which states that "*the participating Member States shall issue coins denominated in euro or in cent and complying with the denominations and technical specifications which the Council may lay down in accordance with the second sentence of Article 105a(2) of the Treaty"* (as first defined in Council Regulation (EC) No 975/98 of 3 May 1998 on denominations and technical specifications of euro coins intended for circulation). These coins are the only coins which have the status of legal tender in those Member States.[11] Electronic payments of less than one cent may be also declined on the basis of Regulation No 974/98, as stated in Article 2 thereof: "As from 1 January 1999 the currency of the participating Member States shall be the euro. The currency unit shall be one euro. One euro shall be divided into one hundred cent." In line with this, all Single Euro Payments Area (SEPA) payment schemes include a lower limit in the "Customer-to-bank Implementation Guidelines" as regards the value of the transaction, which must be €0.01 or more. In this respect,

[11] Regulation No 975/98 establishes that there are eight denominations of euro coin ranging from €0.01 to €2.

regulations and payment schemes currently place a lower limit on the value of payments in Europe.

5.2.3 The user base

The payment market exhibits network effects, meaning that greater use of a product results in an increase in its value. However, network effects do not become significant until a critical mass of users has been achieved. For micropayments to become widely used and able to continue functioning in the long term, a certain number of merchants and consumers need to be using them. With this in mind, micropayment solutions need to be designed in a way that effectively meets the needs of both merchants and consumers, so that both sides of the market can adopt them at the same time. Otherwise, attempts to endorse such solutions will be doomed to failure.

5.3 Social issues

There are various different ways in which consumers can react to the properties of micropayments, some of which may play a key role in determining whether such instruments are adopted. Mental transaction costs can be regarded as the most important factor in this regard.

Mental transaction costs are defined as the hurdle that consumers have to overcome in terms of the effort required to decide whether something is worth buying or not, and they apply irrespective of the price of the item in question. In a paper on micropayments and mental transaction costs, Nick Szabo argues that mental transaction costs fundamentally limit customers' acceptance of finely weighted bundling and pricing. He believes that mental costs tend to outweigh technological costs when it comes to payment systems, so have the potential to play a key role in the adoption of micropayments. In the same vein, Andrew Odlyzko argued in his paper "The Case Against Micropayments" that obstacles to the adoption of micropayments have very little to do with technology, instead being rooted in economics, sociology and psychology. Mental transaction costs are relevant when at least one of the parties involved in a payment transaction is human and may become irrelevant when automated devices conduct transactions among themselves.

In addition, consumers today are used to online services being free of charge and do not expect to pay for them. As a result, content providers and platforms often turn to advertisements as a source of revenue. With this in mind, some might argue that customers' attention is most valuable currency for online providers.

6 Different means of payment and technologies that could be used for micropayments

While some argue that the real constraints limiting the take-up of micropayments are social and economic in nature, most agree that the key limiter lies in the area of technology. In general, conventional payment instruments and systems are not well suited to micropayments in terms of transaction costs and required processing speeds. For example, credit card payments – despite being processed in batches – generate large costs for merchants, which makes them unviable for individual micropayments.

Most recent micropayment initiatives have based their models on DLT – the most prominent form of blockchain technology. While DLT holds much promise for micropayments, it still does not quite seem mature enough. This section presents some thoughts on a number of technologies, including DLT.

6.1 Electronic money

Electronic money[12] (e-money) has been used for payments since the very early days of the internet. With the technological growth and development of online commerce, new and more efficient e-money products have been established and adopted, operating as closed-loop solutions. PayPal is the most successful example of an e-money system, being established in 1998 and growing steadily over the years.

In order to meet the needs of firms selling low-value products and services, PayPal has introduced a model designed especially for micropayments, altering its pricing strategy in order to reduce payment fees. With this micropayment pricing, a payee will receive 80 cents from a €1 transaction, instead of around 60 cents under the normal pricing structure.[13] Despite the introduction of this micropayment pricing model, it can be argued that fees for low-value transactions are still too high. Thus, existing e-money solutions will need to enhance their operations in order to remain competitive in the face of new and more efficient electronic financial solutions for micropayments. This can be attributed to users' growing demand for more efficient solutions in terms of costs and usage.

6.2 Instant payments

In the field of payments, instant settlement in the interbank and end-to-end spheres has been available for some years now. More recently, instant payments have been adopted by increasing numbers of countries around the world.

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12 E-money is broadly defined as an electronic store of monetary value held on a technical device that can be widely used for making payments to entities other than the issuer. The device acts as a pre-paid bearer instrument and does not necessarily involve bank accounts in transactions. See: Electronic Money.

13 For domestic micropayment transactions, PayPal charges 10.0% + €0.10; for a normal transaction, a merchant with a monthly income of less than €2,000 is charged 2.49% + €0.35.

The SEPA Instant Credit Transfer scheme (SCT Inst) and DLT both allow for instantaneous debiting and crediting of users' accounts and 24/7 availability. However, the latter may still constitute a serious competitor for the former when it comes to pricing. Traditional payment systems still rely heavily on intermediaries and incur higher unit costs as a result. Payment intermediation has evolved over the past few years, adding new stakeholders to the payment chain. Although this has been driven by a desire to improve efficiency for consumers, it has also increased transaction costs.

SCT Inst has the potential to become the "new normal" in Europe for account-to-account payments. Although adoption rates are still relatively low, with significant variation across Member States, rapid adoption of SCT Inst is expected in the next few years.[14] In the medium term, SCT Inst could – if market demand and technological advances allow it – become better suited to micropayments. For the time being, however, there are a number of drawbacks that are preventing instant payments from meeting demand for micropayments – mainly a lack of end-user solutions allowing easy, fast and convenient initiation of instant payments (especially online) in Europe and around the world, as well as fraud issues and the involvement of multiple entities in the payment chain (which impacts transaction costs).

In terms of pricing, reduced operating costs mean that the overall costs of SCT Inst have fallen relative to legacy payment systems and have the potential to decline further once SCT Inst achieves critical mass. Consequently, payment service providers should be able to offer SCT Inst to consumers at a very low cost – ideally, free of charge.[15] If SCT Inst is to become the new normal, pricing and unified end-user solutions will be crucial, as they will go a long way to determining whether it is widely adopted for micropayments.

6.3 DLT

DLT has been depicted as a revolutionary innovation, having the potential to radically change the payments industry. In the context of payments, DLT removes the need for a central ledger where payment transactions are recorded by using decentralised units responsible for different steps in the payment process. As such, it enables entities, through the use of established procedures and protocols, to conduct transactions without the need for a central authority.

DLT features such as decentralisation and disintermediation, greater transparency, automation and programmability, immutability and verifiability are viewed as having the potential to improve the efficiency of the payment market, mainly in terms of increased speed, reduced costs and enhanced cyber-resilience.

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14 The European Commission published a legislative proposal for a Regulation amending Regulations (EU) No 260/2012 and (EU) 2021/1230 as regards instant credit transfers in euro in October 2022, requiring that payment service providers that offer regular SEPA credit transfers offer also SEPA instant credit transfers to their customers.

15 The European Commission proposal for a Regulation amending Regulations (EU) No 260/2012 and (EU) 2021/1230 as regards instant credit transfers in euro requires that the charges for SEPA instant credit transfers are equal or lower than the charges for SEPA credit transfers.

In terms of **speed**, DLT is often advocated as a way of improving end-to-end settlement speed by reducing the number of intermediaries involved and making the reconciliation process more efficient (thus reducing credit and liquidity risk). Although blockchain products such as Bitcoin and Ethereum are subject to restrictions when it comes to scalability and speed,[16] their scaling solutions and escrow-based protocols (such as the Lightning Network, which is built on the Bitcoin blockchain and µRaiden (pronounced "Micro Raiden"), which is built on the Ethereum blockchain) enable large volumes of transactions to be processed by blocking funds and recording transfers between balances, especially for small amounts. Lightning Network and µRaiden transactions are conducted off the blockchain, namely on the second-layer payment protocol that sits on the top of the blockchain, allowing instant and nearly unlimited transactions between parties. This addresses the issue of the scalability needed to process large transaction volumes in a very short period of time and at high speed. However, so-called "layer two" solutions come at the expense of settlement finality, which usually occurs downstream on the ledger (on-chain). The viability of layer two solutions for micropayments, though technically feasible, will also depend on the use cases targeted.

The scalability issues with DLT can also be addressed by Directed Acyclic Graph (DAG) – another form of DLT. In contrast to blockchain, it has no blocks; instead, it is a stream of interlinked individual transactions. One example of the DAG DLT is IOTA's Tangle – a network that facilitates people-to-people and people-to-machine but mainly M2M interactions in real time, including no-fee micropayments and secure data transfer.

By using IOTA's network, the Lightning Network or µRaiden, individual machines can communicate autonomously without the need for any intermediaries and thus transfer values. The increasing demand for IoT is evident in today's industry. One example of the future M2M model is smart cars with integrated e-wallets allowing autonomous payments for services such as fuel or battery charging at petrol stations, or parking tickets. They could even allow real-time inter-vehicle communication (e.g. regarding the allocation of high-speed lanes), the acquisition of secure traffic data or the purchase of bandwidth or data as needed and selling these resources when their use is no longer required.[17]

With regard to **costs**, DLT technology has, depending on the configuration of the underlying DLT arrangement, the potential to reduce transaction costs. Its decentralised nature allows P2P transactions to interact directly without relying on a trusted central party (which, in turn, may help to reduce costs). By removing (i) the need for intermediaries, (ii) manual or duplicated procedures (thanks to the automation and programmability of processes) and (iii) the need for regular maintenance of the infrastructure, DLT allows transaction costs to be kept very low. Moreover, the IOTA payment network does not have any actual transaction fees, as

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16 While Visa has a capacity to process about 65,000 transaction messages per second and PayPal can process around 200 transactions, Bitcoin's capacity is only 7 transactions per second and Ethereum's is about 20 transactions per second.

17 There are various possible models here, and some of these IoT payment transactions will not necessarily be characterised as micropayments.

the protocol does not rely on miners.[18] This makes DLT-based systems attractive to both payment service providers and payment service users, as they have different cost structures.

The removal of the central party and distributed data storage can also potentially contribute to increased security by improving **resilience and data integrity**. Spreading information recording across several nodes instead of concentrating it within a single one reduces the risk posed by a single point of failure. However, in its e-krona proof-of-concept, Sveriges Riksbank identified the potential risk associated with the sharing of data between operators of nodes in a DLT network as one of the main challenges. Personal data and data subject to bank secrecy regulations are both shared between nodes. Although data are encrypted, data regarding users other than the end users involved in a specific transaction are still shared. This raises the question of whether DLT complies with the General Data Protection Regulation and bank secrecy regulations.

DLT-based payment systems have the capacity to enhance safety and resilience and are therefore attractive for a variety of financial sector players and authorities. Nevertheless, there are also potential increased risks associated with DLT systems. Recent analysis undertaken by De Nederlandsche Bank[19] found that "the managerial governance of public DLT systems in particular is less horizontal than the decentralised name would suggest and hence entails risks of decision-making contrary to or not in line with the interests of the whole community". De Nederlandsche Bank found that there may be conflicts of interest between the shared objectives of the DLT and the individual objective of a participant. Moreover, financial institutions cannot mitigate risks in public DLTs where there is no central authority that is responsible, accountable and liable.

Although DLT scaling solutions can potentially address some of the challenges associated with the processing of micropayments, they can also pose some problems owing to their immaturity. As DLT is still not mature enough in its development, it remains to be seen whether the stipulated benefits can really be achieved in a real-life operational environment. Consequently, it is still too soon to reach a final verdict on DLT's implications for payments and its ability to outperform traditional payment systems also when it comes to micropayments in the IoT environment.

Depending on DLT or similar technology, stablecoins which can be defined as crypto assets backed by fiat funds or assets with a view to achieve a stable value can also potentially meet the requirements for conducting payments. In this respect, some stablecoin initiatives are attempting to address the issue of micropayments.

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[18] In IOTA, every participant that wants to conduct a transaction has to actively participate in the network by approving two previous transactions. Thus, there is no need for miners to verify blocks and no need for fees to be paid to miners.

[19] See "Governance in systems based on distributed ledger technology (DLT): a comparative study".

6.3.1 Micropayment initiatives based on DLT

Several market initiatives have been launched to examine the potential use of DLT for micropayments. Although DLT has not yet been shown to be sufficiently robust for large-scale implementation, almost all micropayment market initiatives are basing their models on DLT. Although DLT-driven initiatives show that this technology could be suitable (especially for IoT), they have not yet resulted in a common European or global payment system. Here are some DLT-based micropayment initiatives that are already in use or still at an exploratory stage:

- **SatoshiPay** a European company based in Berlin and London, allows online publishers to monetise content via instantaneous low-cost micropayments based on blockchain technology. This enables providers to charge users small fees for individual articles, seconds of video and downloads, offering ad-free content and receiving money instantly with lower fees relative to traditional payment methods. SatoshiPay's wallet, which is based on Stellar blockchain, allows payments at a global level without any intermediaries.
- **ElaadNL**, a knowledge and innovation centre in the Netherlands, established the first IOTA smart charging station for electric vehicles in 2019. The charging station uses IOTA's Tangle DLT technology and takes payment using the IOTA cryptocurrency, with no fees. The charging station operates completely independently and autonomously and takes charge of communication with the e-wallet integrated in the car. In June 2022, ElaadNL opened a new test lab. In addition to the charging of electric passenger cars, they are also testing the charging of electric buses, e-trucks and other forms of electric transport.
- **Mercedes Benz's** parent company Daimler is partnering with the company Riddle&Code on a project looking at how to build a hardware wallet based on blockchain technology that will allow cars to conduct payments. The car's wallet turns the vehicle into an autonomous economic agent and connects it with the surrounding environment, allowing it to make payments to any digital communicative device (toll booths, car parks, etc.).

6.4 Central bank digital currency

A central bank digital currency (CBDC) is a digital form of central bank money that is available to the general public. Central bank money is money that is a liability of the central bank. CBDC can be either retail (used by consumers and companies) or wholesale.[20] At the moment, various CBDC arrangements are being considered, with each potentially having a different impact on the stakeholders involved in a payment transaction.

CBDC-related technological advances could result in a rapidly expanding market for micropayments by enabling the deployment of fast and low-cost money transfers.

[20] Wholesale CBDC refers to the settlement of interbank transfers and related wholesale transactions in central bank reserves.

Intended to serve as legal tender, CBDC would be highly trustworthy while constituting a strong low-cost instrument of financial inclusion, allowing any end user to be provided with payment services free of charge. To the extent that CBDC could enable instant payments, either free of charge or at very low cost, at a global level, various new opportunities could arise for micropayments. The Bank for International Settlements[21] has already highlighted the potential risks associated with linking a token-based retail CBDC with micropayments, saying: "A token-based system would ensure universal access – as anybody can obtain a digital signature – and it would offer good privacy by default. It would also allow the CBDC to interface with communication protocols, i.e. be the basis for micropayments in the internet of things. But the downsides are severe. One is the high risk of losing funds if end users fail to keep their private key secret. Moreover, challenges would arise in designing an effective AML/CFT framework for such a system. Law enforcement authorities would run into difficulties when seeking to identify claim owners or follow money flows, just as with cash or bearer securities. Retail CBDCs would thus need additional safeguards if they followed this route."

The Eurosystem's digital euro project, which is focusing on retail payments with a view to ensuring that public money remains widely accessible and usable for daily transactions, could also address the issue of micropayments. However, as that project is still in the investigation phase, it is difficult to assess whether any future digital euro will be suitable for micropayments at this stage.

7 Potential implications of micropayments for the European retail payment market

The micropayment market is expected to grow in the future as new business models and services are offered to payment service users. While micropayments for online content in the e-commerce sphere have huge growth potential, it is IoT that could open up the greatest opportunities for micropayments. The development of micropayments may be subject to changes prompted by technical, market, regulatory and social developments and can bring a new complexity to the retail payment market, affecting various different stakeholders. The transition from the current situation (where micropayments play only a minor role) to full implementation will be gradual and will depend on the speed with which state-of-the-art payment systems and end-user solutions are deployed for online micropayments and M2M payments.

Micropayments present various opportunities in the field of digital retail payments. From the point of view of payment service providers, micropayments could lead to new business opportunities and impact current revenue streams by making economically unviable transactions profitable. Revenues from legacy payment instruments will be largely unaffected, as micropayments will probably not replace them to any significant extent. In the area of e-commerce, micropayments have not been very well implemented yet and are one

[21] See "The technology of retail central bank digital currency".

of a number of alternative revenue streams that are yet to be explored. However, an efficient end-user solution for e-commerce micropayments at EU level is yet to be established. Instant payments backed by a pan-European point-of-interaction solution allowing payment features such as chargebacks/refunds could, in principle, develop the ability to support these payments by changing the way in which users make micropayments online and creating new revenue streams for payment service providers.

Moreover, further digital onboarding and the rise of IoT may leverage new services while offering added value to payment service providers and users. Building on early successes, some European payment service providers are already experimenting with IoT to improve customers' experiences while reducing their own operating costs and increasing their revenues. In this respect, a combination of IoT and efficient payment solutions could foster the application of micropayments and facilitate the establishment of a new payment marketplace. Furthermore, banks could increase their revenues thanks to the development of new value-added services that users agree to be charged for. While IoT has certain difficulties to overcome in terms of implementation, the banking industry is starting to find ways to leverage its capabilities. **Micropayments are likely to play a major role in e-commerce and – in particular – IoT over the next few years, becoming a standard part of our daily lives. As they are likely to impact existing business models in the payment industry, Europe's payment service providers might benefit by including them in their own payment strategies.**

The processing of micropayments requires scalable, sustainable and very cost-efficient payment systems, especially as regards IoT. Legacy payment systems are technically capable of processing online micropayments, as transaction volumes should not be too significant. However, that might not be the case for IoT-related transactions. First and foremost, legacy payment systems would need to dramatically increase their scalability. Of course, the question that arises is how much room for scalability there is in legacy systems. More specifically, are these systems agile enough to adapt to the demands of IoT? **Given that they are not so technically advanced, the European payment industry should investigate whether existing payment systems require any enhancements – and if so, what those enhancements should be – or whether alternative payment systems would need to be developed in order to effectively address the evolving market requirements in the case of IoT. As regards DLT, market participants attending the recent meeting with the ECB on micropayments believe that this technology could potentially be used for micropayments in the longer term, but is not sufficiently mature at present.**

Under existing regulations and payment scheme rules, electronic payments of less than €0.01 may be declined. Thus, the current legal framework and scheme rules might need to be adjusted. At present, market conditions are not calling for very low-value payments, as e-commerce micropayments for streaming media are usually higher than €0.01, and it seems that existing payment schemes are sufficiently able to cater for micropayments in the context of the business cases in question. Moreover, the recent exchange with market participants also showed

that they view micropayments very differently. According to their business cases, these payments can range from €7 to €100. In the future, though, IoT may open up new business cases for very low-value payments, especially payments of less than €0.01. As these very low-value payments are likely to be repeated frequently, millions of micropayments will be executed. However, to optimise the settlement of very low value payments these do not need to be processed individually but rather cumulated and processed in batches. This allows to avoid unnecessary transactions costs in the absence of any material credit risk exposure. Nevertheless, with IoT, the concept of micropayments might need to be redefined and a new definition of micropayments established. Furthermore, the current regulations and rules will most likely need to be adapted in line with these changes. European payment service users may be exposed to risks if the regulatory regime governing micropayments is not sufficiently sound.

8 Conclusion

Micropayments are believed to have the potential to grow significantly over the next few years, particularly in the context of IoT.

Thus far, micropayment applications for online content have consistently failed to succeed owing to a lack of user-friendly front-end solutions and cost-efficient payment systems to process them; however, some market-led initiatives are continuing in this domain. Successful micropayment systems and solutions will not only minimise transaction costs, but make such transactions a common, established practice. In terms of technology, it is worth noting that most recent initiatives have used DLT, although there does not seem to be any reason not to rely on instant payment technology (complemented as needed by end-user solutions and application programming interfaces).

However, all of those DLT-based initiatives are still in the investigation phase and have yet to prove their economic viability also for micropayments between IoT devices. DLT-based micropayments are still not part of our daily life and may not be widely adopted until more convincing business cases appear. And even then, success is not guaranteed, given all of the obstacles that they might face.

While current analysis and exchanges with market players do not highlight any major issues with micropayments, it is quite likely that new micropayment models will emerge in the future, affecting the European payment market. The Eurosystem will continue to monitor developments in this regard and act as a catalyst, seeking to promote safety and efficiency in the field of retail payments and fostering the implementation of innovative and efficient pan-European payments.

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