CBDCs, Payment Firms, and Geopolitics

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Abstract

We analyze the effect of a major central bank digital currency (CBDC) – the digital euro – on the payment industry to find remarkably heterogeneous effects. Stock prices of U.S. payment firms *decrease*, while stock prices of European payment firms *increase* in response to positive announcements on the digital euro. Bank stocks do not react. We estimate a loss in market capitalization of USD 127 billion for U.S. payment firms, vis-a-vis a gain of USD 23 billion for European payment firms. Our results emphasize the medium-of-exchange function of CBDCs and point to a novel geopolitical dimension of CBDCs: enhanced autonomy in payments.

Keywords: Central Bank Digital Currencies (CBDCs), Payment Firms, Digital Euro, Commercial Banks, Geopolitics, Strategic Autonomy

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1. Introduction

More than 100 countries, representing 98% of global GDP, are exploring central bank digital currencies (CBDCs) (Atlantic Council, 2024). CBDCs are digital liabilities of central banks held directly by the public. Like conventional currencies, CBDCs can function as a medium of exchange as well as a store of value. These functions are currently facilitated by financial intermediaries such as payment firms and deposit-taking commercial banks, raising the question of how the introduction of CBDCs would affect the respective intermediaries. Our paper addresses this question by analyzing stock market reactions to important announcements regarding a major CBDC project: the digital euro. We delve into important heterogeneities in both the cross-section of firms and in the cross-section of announcements and provide supporting evidence from actions and communications of policymakers and private-sector entities. So far, the academic discussion on CBDCs has primarily concerned the banking system, implicitly focusing on the store-of-value function. In contrast to this, we emphasize the medium-of-exchange function of CBDCs, and thereby extend the discussion to payment firms, which are an important, growing part of financial markets.

There is no established definition of payment firms. Standard industry codes currently assign payment firms to various industries, ranging from financial services to information technology, e-commerce, or manufacturing. Therefore, we start by developing an objective method to classify firms as payment firms based on the combination of a firm's SIC code and specific keywords in its business description. Using our novel classification method, we highlight differences in business models between payment firms and commercial banks and document the rise of payment firms over the last two decades. At the height of its valuation in 2021, the aggregate market capitalization of the U.S. payment industry was almost at par with the aggregate market capitalization of all U.S. commercial banks, suggesting that payment firms constitute a distinct and important category within the financial sector that is worth studying more closely.

Next, we focus on the main empirical question of the paper and analyze how the potential introduction of a major CBDC affects the valuations of payment firms and commercial banks. Since no advanced economy has actually introduced a CBDC on a larger scale so far, we conduct event studies around forward-looking central bank communication on

the digital euro, the leading advanced-economy CBDC project. For this, we rely on a database maintained by the Bank for International Settlements (BIS), which comprises a comprehensive set of speeches on the digital euro over the 2016 to 2022 period.[1] Usefully, the database includes an independent assessment of the sentiment expressed in each speech regarding the future introduction of the digital euro (Auer, Cornelli, and Frost, 2020).

We document a striking pattern: stock prices of European payment firms *increase*, while stock prices of U.S. payment firms *decrease* in response to positive speeches on the digital euro. Bank stocks do not react. When central bank speeches on the digital euro carry a positive stance, a value-weighted index of European payment firms *increases* by 52 basis points on the day the speech is given. Simultaneously, an equivalent index of U.S. payment firms *decreases* by 19 basis points. The stock price effects for U.S. and European banks are insignificant. For our sample period, we estimate an aggregate loss in market capitalization of USD 127 billion for U.S. payment firms and an aggregate gain in market capitalization of USD 23 billion for European payment firms. This net loss is consistent with the often-cited argument that the digital euro would make payment services less costly for the public and the anticipation of a corresponding drop in rents for the payment industry (ECB, 2023).

We conduct several robustness tests. First, we run event studies around central bank speeches that cover the topic of CBDCs but have a neutral stance on their future introduction. Reassuringly, we find a closely estimated zero announcement return for these events. The result suggests it is not the central bank speeches per se that matter for the observed stock price reactions, but indeed the communicated stance on CBDCs. Second, we exploit heterogeneity across different types of U.S. payment firms. Specifically, we show that (i) the negative U.S. results stem entirely from U.S. payment firms that are internationally active, (ii) results are stronger for payment firms that derive a larger part of their revenues from payment services, and (iii) results are weaker for payment firms that have a significant lending business, such as American Express and Discover. Third, we validate the robustness of our results to model risk

[1] For the period from 2016 to 2022, the BIS database contains 157 observations (related to 136 unique days) that are associated with central banks from the Eurozone. This includes 149 speeches and a limited number of observations related to communication in formats other than speeches (2x newspaper op-eds, 5x interviews, and 1x blog post). For simplicity, we refer to all forms of central bank communication as 'speeches' throughout the rest of the paper.

by running 2,592 regression specifications that vary, for example, the asset pricing model, the choice of fixed effects, or the classification of payment firms. Reassuringly, every single one of the 2,592 specifications suggests a negative effect for U.S. payment firms and a positive effect for European payment firms. Fourth, we manually review the transcripts of all speeches with a positive stance on the digital euro and establish that abnormal announcement returns are concentrated around speeches that are non-generic in nature and that plausibly update investors' priors. A set of roughly half of the positive-stance speeches explains almost 80% of the cumulative abnormal announcement returns.

Our findings are consistent with the digital euro being focused on the means-of-payment function rather than the store-of-value function. They also point to a geopolitical dimension that has been largely ignored in research on CBDCs so far: enhanced autonomy in payments. Payment systems constitute critical infrastructure, and CBDCs can promote local control over payment schemes, thereby reducing the reliance on foreign payment providers. This autonomy argument is particularly relevant in the context of the digital euro, as U.S. companies such as Visa, Mastercard, and PayPal currently play a major role in the European payment landscape. The pattern of our results (negative returns for U.S. payment firms, positive returns for European payment firms, insignificant returns for U.S. and European banks) is difficult to rationalize through explanations other than a strategic-autonomy-in-payments-narrative. Specifically, the pattern is inconsistent with the speeches conveying general news about the financial industry, the broader economy, the regulatory environment, or the competitiveness of the Eurozone relative to the United States. When considered in isolation, our findings for the individual groups of firms might be consistent with alternative explanations. However, collectively, they strongly point towards a joint hypothesis: the digital euro is, at its heart, driven by a desire for strategic autonomy in payments.

Generally, strategic autonomy has been a guiding principle of European Union policy over the past years (Damen, 2022) and refers to the capacity to act autonomously in strategically important policy areas. We provide tangible support for the strategic autonomy hypothesis by collecting anecdotal evidence from quotes and actions of European central bankers and policymakers. First, we analyze the composition of the key ECB advisory body for the digital euro, the so-called Digital Euro Market Advisory Group (DE-MAG). Representation in the

DE-MAG is heavily skewed towards European payment firms, with 29 out of its 30 members coming from firms based in Europe, despite U.S. payment firms being major players in the European payment market. Second, European payment firms were responsible for developing four out of five prototypes for the digital euro. The selected firms highlighted their mandates prominently in their letters to shareholders in their annual reports, suggesting that winning the selection process represented major achievements for the respective firms. Third, the EU commissioner responsible for the draft regulation on the digital euro explicitly stated an overreliance on Visa, Mastercard, and PayPal as one of the key rationales for the digital euro. Fourth, when analyzing the content of central bank speeches more closely, we find a dramatic increase in speeches that highlight "strategic autonomy" in the context of the digital euro. While not a single central bank speech motivated the digital euro with strategic autonomy until 2018, almost half of all speeches in 2022 referred to the strategic-autonomy-motive. Fifth, private-sector firm communication reveals that: (i) merchant associations support the digital euro because they expect lower fees, (ii) U.S. payment firms oppose the digital euro because they view it as a business risk, and (iii) European payment firms endorse the digital euro because they recognize lucrative business opportunities.

Our paper contributes to the literature on CBDCs as well as to the literature on payment intermediaries. The literature on CBDCs is mostly theoretical in nature due to the fact that no major economy has introduced a CBDC on a larger scale so far. Existing papers discuss various design choices of CBDCs and analyze how CBDCs affect monetary policy (Bordo and Levin, 2017; Brunnermeier, James, and Landau, 2019; Meaning et al., 2021; Barrdear and Kumhof, 2022; Minesso, Mehl, and Stracca, 2022), financial stability (Bindseil, 2019; Brunnermeier and Niepelt, 2019; Fernández-Villaverde et al., 2021; Williamson, 2022; Schilling, Fernández-Villaverde, and Uhlig, 2024), and the potential effects of CBDCs on commercial banks (Niepelt, 2018; Andolfatto, 2021; Chiu et al., 2023; Duffie, 2019; Duffie and Economy, 2022; Keister and Sanches, 2023; Williamson, 2022b; Whited, Wu, and Xiao, 2023; Burlon et al., 2024).

Within the CBDC literature, our work is most intimately related to the subset of studies addressing the adoption of CBDCs (Khiaonarong and Humphrey, 2019; Allen et al., 2020; Garratt and Van Oordt, 2021; Ahnert, Hoffmann, and Monnet, 2022; Ahnert et al., 2022; Davoodalhosseini, 2022; Li, 2023). These studies point to transaction cost reductions, privacy

considerations, and the potential redundancy of certain financial intermediaries. Highlighted concerns about CBDCs typically refer to the potential erosion of commercial bank deposits when facing competition from central banks as well as to the implied effects on bank liquidity, funding costs, interest rate risk, lending, and runs. Notably, these concerns predominantly relate to the store-of-value function of CBDCs.

To the best of our knowledge, we are the first to explicitly examine the medium-of-exchange function of CBDCs and to empirically analyze the effects of their potential introduction on payment firms. In addition, our paper highlights a novel geopolitical dimension of CBDCs that has been largely ignored by the literature so far: enhanced autonomy in payments.

Beyond the literature on CBDCs, our work is also related to a broad literature on payments (for overviews, see Quinn and Roberds, 2008; Kahn and Roberds, 2009; Koulayev et al., 2016). Existing papers study the use of credit cards by households (Ausubel, 1991; Calem and Mester, 1995; Edelman and Wright, 2015; Gross and Souleles, 2002; Meier and Sprenger, 2010; Telyukova, 2013; Liberman, 2016; Stango and Zinman, 2016; Ponce, Seira, and Zamarripa, 2017), the introduction of the option to pay with cash (Alvarez and Argente, 2022), mobile wallets and QR-codes (Agarwal et al., 2019; Crouzet, Gupta, and Mezzanotti, 2023), contactless payment methods based on payment cards (Bounie and Camara, 2020, Brown et al., 2022), and real-time digital payments (Dubey and Purnanandam, 2023; Sarkisyan, 2023). Payments are one of the prime examples of two-sided markets and various papers analyze competition, pricing, and regulation (Baxter, 1983; Katz, 2001; Rochet and Tirole 2002; Rochet and Tirole, 2003; Shy and Wang, 2011; Jambulapati and Stavins, 2014; Agarwal et al., 2015; Kay, Manuszak, and Vojtech, 2018; Wang, 2023). Payment information can help mitigate information asymmetries and, in turn, facilitate the core lending operations of financial intermediaries (e.g., Black, 1975; Fama, 1985; Berlin and Mester, 1999; Mester, Nakamura, and Renault, 2007; Norden and Weber, 2010; Puri, Rocholl, and Steffen, 2017). Ghosh, Vallee, and Zeng (2022) empirically document the informational synergies between cashless payments and lending. Parlour, Rajan, and Zhu (2022) develop a model in which FinTech payment providers disrupt the flow of information to traditional banks and thus affect traditional banks' lending business. To the best of our knowledge, we are the first to develop an objective method to

classify firms as payment firms. We also contribute to the payment literature by (i) analyzing the effect of CBDCs on payment firms' business models and (ii) documenting a geopolitical motive for interventions in payment markets.

2. Institutional Setting

A central bank digital currency (CBDC) is a digital version of a jurisdiction's fiat currency, issued and regulated by the jurisdiction's central bank. Unlike other forms of electronic money, such as book money deposited with private-sector credit institutions, a CBDC is a public form of money that represents a direct liability of the central bank (equivalent to coins and banknotes). CBDCs are typically designed for use by the general public, aiming to facilitate everyday transactions involving households or businesses.[2] Despite the common association, CBDCs are not inherently cryptocurrencies, and distributed ledger technology is not a defining feature of a CBDC.

As of the beginning of 2024, only a small number of CBDCs with limited global economic impact have been issued.[3] Simultaneously, more than 100 countries, representing 98% of the global gross domestic product, are exploring the future issuance of a CBDC (Atlantic Council, 2024). The most advanced CBDC initiative among the major global central banks is the digital euro project by the European Central Bank (ECB). After the release of an initial report in October 2020, the project was officially launched in July 2021 with the start of the investigation phase. In November 2023, the project progressed to the preparation phase. A final decision on the future issuance of a digital euro will follow at a later stage. Yet, as of early 2024, it is widely anticipated that the ECB will eventually introduce some form of retail CBDC (see, e.g., Sandbu, 2024). To mitigate the associated disintermediation risks for the banking sector, the ECB is contemplating measures such as a maximum holding limit of EUR 3,000 for

[2] In addition to CBDCs that are accessible to the general public, wholesale CBDCs target banks and other financial institutions, aiming to facilitate large-scale financial transactions.
[3] Existing CBDCs are the Sand Dollar (launched by the Central Bank of Bahamas in 2020), the eNaira (launched by the Central Bank of Nigeria in 2021), and the JAM-DEX (launched by the Central Bank of Jamaica in 2023). In addition, there are several CBDC pilot projects, including the e-CNY by the People's Bank of China.

households and EUR 0 for businesses[4] and a disincentivizing remuneration scheme with a zero-interest rate (ECB, 2022b). The digital euro will generally be distributed via so-called payment service providers (ECB, 2023), which would be compensated for their services according to a compensation model designed by the ECB. The European Commission has drafted regulations on the establishment of the digital euro that would generally require merchants to accept the digital euro.[5]

Note that CBDCs can be implemented with different design choices. The digital euro comes with a specific design (retail CBDC, maximum holding limit, zero interest rate, legislative backing with a requirement to accept the digital euro, distribution via private-sector payment service providers). All our results should be interpreted within this context, and other design choices might affect payment firms and banks differently.[6]

3. Firm Classification and Descriptive Statistics

3.1 Classification of Commercial Banks and Payment Firms

Our data set ranges from 2000 to 2022. We cover listed firms located in the United States and the Eurozone based on *Compustat*. Our focus is on commercial banks and payment firms. In line with Gandhi and Lustig (2015), we define commercial banks as firms whose SIC codes start with '60'.[7] There is no standard approach to classifying payment firms in the literature. We therefore develop a simple definition of payment firms based on the following two criteria:

[4] A maximum holding limit does not affect the ability to make or receive payments with a higher value – in such cases additional funds will be transferred automatically from and to a user's commercial bank account via a so-called "waterfall / reverse waterfall" mechanism. The contemplated holding limit of EUR 0 for businesses thus implies that businesses can only accept payments in the digital euro if they have a bank account where digital euro payments are immediately transferred to.

[5] The draft regulation 2023/0212(COD) is available via https://oeil.secure.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2023/0212(COD)&l=en

[6] Expert recommendations for a digital dollar resemble key features of the digital euro, such as distribution via private-sector payment service providers as well as regulation to foster broad participation and interoperability (Duffie, 2021). The Indian (UPI) and Brazilian (Pix) payment services are also distributed via private-sector payment service providers. UPI was free of charge at the beginning, but large merchants will need to pay a fee to private-sector payment service providers in the future (Kawale, 2024).

[7] We make two manual adjustments to the SIC code-based firm classification. First, we classify Citigroup (SIC code '6199') as commercial bank. Second, we remove Coinbase (SIC code '6099') from the set of commercial banks. Note that Gandhi and Lustig (2015) use header SIC code data (from *CRSP*) while we rely on historical SIC code data (from *Compustat*). In the *CRSP* database, bank holding companies are sometimes classified with SIC codes starting with '67'. In the *Compustat* database, bank holding companies that are mainly commercial banks have SIC codes starting with '60'.

(i) The historical *Compustat* business description contains at least one of the words 'payment' or 'merchant solution'; and

(ii) the historical SIC code is '6099' (*Functions related to Depository Banking*; examples: Visa, Mastercard), '6141' (*Personal Credit Institutions*; examples: American Express, Discover), or does not start with '6'.

Condition (ii) ensures that we only identify dedicated payment firms rather than picking up general financial institutions for which payment services constitute just one out of several business lines. We cross-check our definition in two ways. First, we compare it against industry reports from Nilson, the key provider of statistics on the payment industry. We find that our definition has a 93% overlap with the subjective common-sense definition used in these industry reports.[8] Second, we take advantage of a change in the Global Industry Classification Standard (GICS) that became effective in March 2023 (MSCI, 2022) – after the first draft of our paper. As part of the update, a new financial sub-industry called *Transaction & Payment Processing Services* (code '40201060') was introduced. The update corroborates our view that payment firms' activities are sufficiently distinct to warrant the creation of a separate sub-industry, but closely aligned with the financial sector. While the GICS reclassification is available from March 2023 forward, our definition can be applied historically as well. Using the March 2023 GICS classification applied to end-of-2022 data, the *Transaction & Payment Processing Services* sub-industry has a 98% overlap with our definition.[9]

For 2022, our definition yields 45 payment firms from the United States and 6 payment firms from the Eurozone. Out of the 45 U.S. payment firms, 29 firms have a SIC code starting with '73' (*Business Services*; examples: PayPal, Block/Square), 6 firms have the SIC code '6099' (*Functions related to Depository Banking*, examples: Visa, Mastercard), 4 firms have the SIC code '6141' (*Personal Credit Institutions*; example: Discover), and 6 firms have other

[8] For 2021 (the latest full-year Nilson report available to us), our definition of payment firms results in a U.S. payment sector market capitalization of USD 1.538 trillion, while the definition from Nilson results in a U.S. payment sector market capitalization of USD 1.613 trillion, of which USD 1.505 trillion overlaps with our definition.

[9] For 2022, our definition of payment firms results in a U.S. payment sector market capitalization of USD 1.229 trillion, while the GICS-based definition results in a U.S. payment sector market capitalization of USD 1.091 trillion, of which USD 1.075 trillion overlaps with our definition. The main difference is the classification of payment firms that also provide significant consumer credit, in particular American Express and Discover, that we classify as payment firms while the GICS system classifies these firms under the sub-industry *Consumer Credit* ('40202010').

SIC codes. All 6 payment firms from the Eurozone have a SIC code starting with '73'. The aggregate market capitalization of payment firms is concentrated in SIC code '6099' (59%), SIC codes starting with '73' (30%), and SIC code '6141' (11%). The remaining SIC codes account for less than 1% of the aggregate market capitalization. Due to our reliance on historical rather than header data, a given firm might change its classification over time, for example, if it changes its business model and moves to a different SIC code category. We find that firms switching their classification at least once between 2000 and 2022 represent 17% of the end-of-year 2022 payment sector market capitalization.

Internet Appendix Table A.1 provides a detailed overview of the companies involved in (retail) payment transactions. Our approach is to cover firms throughout the entire payment value chain, although our data has one key limitation. We only focus on dedicated payment firms and do not cover firms that derive some, but not a major part of their market capitalization from payment services. In particular, we do not include technology firms like Apple, and we cannot isolate the payment-related component of traditional banks' market capitalization. Consequently, our estimate of the size of the payment sector represents only a lower bound.

3.2 Descriptive Statistics

3.2.1 Size and Growth of the Payment Sector Relative to Commercial Banks

Figure 1 illustrates the evolution of market capitalizations for payment firms and commercial banks in the United States and the Eurozone. The figure indicates a significant increase in the valuation of payment firms over time. As of the year 2000, payment firms' aggregate market capitalization was negligible, accounting for only 4% of commercial banks' market capitalization in the United States and less than 1% of commercial banks' market capitalization in the Eurozone. By 2020, however, the ratio had risen to 90% in the United States and 24% in the Eurozone (before dropping back to 69% and 13% by the end of 2022, respectively). In absolute terms, payment firms' aggregate market capitalization increased from USD 47 billion in 2000 to USD 1,306 billion in 2022 (+2,675%). The market capitalization of commercial banks, on the other hand, only went up from USD 1,930 billion to USD 2,393 billion (+24%). In separate tests, we confirm that the observed rise in payment firms' market capitalization is not simply the result of a composition effect (i.e., new listings in the payment sector) but mainly

driven by a return effect (i.e., an increase in market capitalizations of existing payment firms). As such, a value-weighted index of U.S. payment firm stocks would have grown by a factor of 13.6 between 2000 and 2022, significantly outperforming commercial banks (2.7).

Zooming in on individual entities, Table 1 presents the most valuable listed payment firms and commercial banks as of year-end 2022. Remarkably, five out of the top ten firms in the United States were payment firms (Visa, USD 430 billion; Mastercard, USD 332 billion; American Express, USD 110 billion; PayPal, USD 81 billion; Fiserv, USD 64 billion). Firms from the Eurozone have significantly lower valuations than their U.S. peers, reflecting the global dominance of the U.S. financial sector. Despite the limited number of listed payment firms from the Eurozone, there are still four such firms with market capitalizations in excess of USD 10 billion (Adyen, USD 43 billion; Edenred, USD 14 billion; Worldline, USD 11 billion; Nexi, USD 10 billion).

3.2.2 Economic Characteristics of the Payment Sector Relative to Commercial Banks

Table 2 provides key financial statistics for the payment and commercial banking sectors. We highlight two characteristics that are consistent with the observed rise in payment firms' market capitalizations over the past two decades. First, relative to commercial banks, payment firms are highly profitable. For example, the average annual return on assets (ROA) in the U.S. payment sector is 4.3% – more than four times higher than in the commercial banking sector (0.9%). The pattern is similar for the Eurozone, where payment firms' ROA is 2.3% compared with 0.2% for commercial banks. Second, payment firms are high-growth firms. During the sample period, net revenues of payment firms increased more than sixteen-fold from USD 15.4 billion in 2000 to USD 257.4 billion in 2022. On an annual basis, the increase corresponds to value-weighted annual growth rates of 9.0% in the United States and 18.9 % in the Eurozone, respectively. This compares to growth rates of merely 5.4% and 2.1% in the commercial banking sector. Overall, the statistics are consistent with the existence of substantial rents in the payment sector and the narrative that the shift towards digital payments has resulted in a notable expansion of the payment industry.

In addition to explaining the observed rise in market capitalizations, Table 2 reveals certain characteristics that set payment firms apart from other players in the financial industry.

Relative to commercial banks, payment firms have a notably smaller asset base and maintain lower financial leverage. Moreover, there are clear disparities in business models. Unlike commercial banks, typical payment firms derive, at most, a modest proportion of their earnings from interest. In the United States, for example, net interest income accounts for only 6.9% of payment firms' net revenues but contributes 55.1% of commercial banks' net revenues.[10] Although these characteristics alone may not be sufficient to unambiguously tell apart a payment firm from other financial entities, they all the more underscore the need for a distinct and objective classification.

4. Payment Firms, Commercial Banks, and the Digital Euro

4.1 Event Study Setup

In this section, we analyze how the stocks of payment firms and commercial banks react to official communication on the digital euro. The logic of our empirical approach is as follows. Assume there is new information $\eta_i \in$ {positive, negative} that updates market participants' expectations about the adoption of the digital euro. If the digital euro fosters European payment firms at the expense of U.S. payment firms, stock prices of European payment firms should increase while stock prices of U.S. payment firms should decrease in response to positive information about the expected adoption of the digital euro.

To test this conjecture, we study particular pieces of information η_i that update the market's expectations about the future adoption of the digital euro and analyze firms' stock price reactions in an event study setting. Specifically, we exploit that central banks regularly communicate their stances on important policy topics via speeches. Over the period from 2016 to 2022, European central bankers gave various speeches articulating their stance on the introduction of the digital euro. We rely on a database managed by the Bank for International Settlements (BIS), which systematically collects these speeches as well as other forms of communication on the digital euro (Auer, Cornelli, and Frost, 2020). A nice feature of the database is that it contains a score for each observation's stance towards the introduction of the digital euro, providing us with an external measure of communication sentiment. The sentiment

[10] The ratios are based on firms representing 99% of the net revenues of banks and 80% of the net revenues of payment firms in our sample, as we lack detailed data on the remaining firms.

of an observation can be +1 for speeches with a positive stance towards the introduction of the digital euro, 0 for speeches with a neutral stance towards the introduction of the digital euro, or -1 for speeches with a negative stance towards the introduction of the digital euro. Figure 2 depicts a timeline of central bank speeches on the digital euro by stance. In total, our data set includes 136 observations, of which 69 have a positive stance, 58 a neutral stance, and 9 a negative stance towards the introduction of the digital euro. We consider speeches from central bank representatives of both the ECB and individual member countries of the Eurozone (e.g., the Bundesbank, the Banque de France, the Banca d'Italia, etc.). Speeches are more frequent in the later years (2020 to 2022) and the sentiment towards the digital euro has gradually become more positive over time. Since the BIS database does not always include precise information about when a particular speech was given, we hand-collect the respective information from public sources. The timing information allows us to precisely assign speeches to specific trading days.[11]

We employ an event study approach to examine the stock market reactions of various types of firms to central bank speeches, contingent upon the speech sentiment. Specifically, we estimate panel regressions of the following form:

$$R_{i,t} = ß_0 + ß_1 PositiveSentiment_t + ß_2 Mkt_t + ß_3 Controls + \varepsilon_{i,t} \qquad (1)$$

$R_{i,t}$ is the daily stock return of firm i on day t, $Positive\ Sentiment_t$ is a dummy variable that takes a value of one on days with a positive speech on the digital euro and otherwise takes a value of zero, Mkt_t is the daily return of the market in excess of the risk-free rate (region-specific), *Controls* is a vector of control variables that varies across specifications, and ε_{it} is an error term. Throughout all specifications, we cluster standard errors at the date level and weigh observations by firms' previous day's market capitalization. The coefficient of interest is the *Positive Sentiment* coefficient β_1, which captures firms' abnormal stock returns associated with a positive central bank speech on the digital euro.

Our event study approach relies on the assumption that the content of a given speech is not anticipated before the speech is given. In addition, for market prices to incorporate any new

[11] We were able to collect the correct date for all observations and the precise time of the day for 73% of observations. In cases where timing data is not available, we assume the speech was given at 12:00 pm local time. Note that the assignment of trading days to speeches can differ between Europe and the U.S. due to the time difference between Europe and the U.S.

information, the speech content needs to be widely available on the day it is delivered. In practice, central banks follow strict procedures to avoid leakages prior to any communication, and they distribute speech protocols to the public at the beginning of a speech.[12]

4.2 Main Event Study Results

4.2.1 Payment Firms

Table 3 presents the main results of the paper based on event study panel regressions of the form outlined in Equation (1). Overall, the results strongly support the narrative that the adoption of the digital euro would be positive news for payment firms from the Eurozone and negative news for payment firms from the United States.

In Panel A of Table 3, the dependent variables are daily stock returns of payment firms from the Eurozone. The baseline specification in column (1) suggests that for these European payment firms, positive central bank speeches on the digital euro are associated with positive abnormal returns of +43 basis points (*t*-statistic = 2.28). Except for the market factor, the baseline specification does not include any control variables. To address potential concerns that this one-factor specification might be too simplistic to adequately model expected returns, we enhance the model by incorporating common (region-specific) stock return factors from the asset pricing literature. Specifically, we extend the regression model by including all five Fama-French factors (Fama and French, 2015), and the momentum factor (Carhart, 1997). The results, shown in column (2), remain largely unchanged (+44 basis points, *t*-statistic = 2.41). During the sample period, valuations of firms in certain industries, especially technology firms, experienced a significant increase. These industry-specific trends might not be fully captured by the common stock return factors. To address the possibility that our results stem from spurious correlations between payment firms and specific industries, we add abnormal returns of various industry indices as control variables.[13] As indicated in column (3), the earlier findings

[12] Pursuant to Article 8 of the ECB's Code of Conduct for high-level ECB officials 2022/C 478/03: *"[Members of high-level ECB bodies and alternates] shall accept speaking engagements at events where their remarks are potentially market-sensitive only if these remarks are published on their respective institution's website, in principle at the start of the speech, or if the event can be monitored and followed directly by the general public (e.g. via a live webcast), or if the event is attended by media representatives who could report in real time."*

[13] For the Eurozone regressions, we consider the following Euro Stoxx indices as proxies for the performance of specific industries: *Telecommunications*, *Consumer Discretionary*, *Consumer Staples*, *Energy*, *Healthcare*,

become even stronger and statistically significant at the 1% level (+47 basis points, *t*-statistic = 2.90). Another potential concern relates to the uniqueness of our sample period, which extends from 2016 to 2022. It is conceivable that payment firms benefitted from certain one-off effects related to the COVID-19 pandemic, implying that the observed outperformance might, in fact, be unrelated to central bank communication (see e.g., World Bank, 2022). We address this possibility by adding year-times-quarter fixed effects to the regression model. Based on this tightened specification in column (4), positive central bank speeches on the digital euro are associated with positive abnormal returns of +52 basis points (*t*-statistic = 2.99). As a placebo test, we also carry out event studies around central bank speeches that address the digital euro but have a neutral stance on its adoption. Reassuringly, we find a closely estimated zero announcement return for these observations, as reported in column (5). The placebo test suggests that what matters is not the discussion around the digital euro per se but, indeed, the central bank's stance on the future adoption of the digital euro.[14]

In Panel B of Table 3, the dependent variables are daily stock returns of payment firms from the United States. We find that the return pattern is exactly opposite to the return pattern for the European payment firms: positive central bank speeches on the digital euro are associated with negative abnormal returns for U.S. payment firms. In absolute terms, the economic magnitude of the effect is somewhat smaller than that of the corresponding Eurozone regressions, with announcement returns varying between -18 basis points and -20 basis points depending on the specification (*t*-statistic between -1.78 and -2.10).[15] The placebo test in

Industrials, *Technology*, *Materials*, *Real Estate*, and *Utilities*. When calculating abnormal returns for these indices, we consider rolling windows of 250 trading days and, again, control for all five Fama-French factors (Fama and French, 2015), and the momentum factor (Carhart, 1997).

[14] A natural extension of our event study design would involve conducting tests based on central bank speeches with a negative stance towards the digital euro. However, the number of such events is significantly lower than the number of events with a positive or neutral sentiment (9 versus 69 and 58 observations, respectively). Consequently, the statistical power of such tests is very limited, and we almost always find statistically insignificant results with large confidence intervals for speeches with a negative sentiment. Additionally, all speeches with an explicitly negative sentiment occurred at the beginning of our sample period (until October 2020). During this time, a negative-stance speech towards the digital euro might not have been unexpected from the view of market participants.

[15] For columns (2) to (5) of the U.S. regressions, we consider the following S&P 500 subindices as proxies for the performance of specific industries (equivalent to the Euro Stoxx indices for the Eurozone regressions): *Communication Services*, *Consumer Discretionary*, *Consumer Staples*, *Energy*, *Healthcare*, *Industrials*, *Information Technology*, *Materials*, *Real Estate*, and *Utilities*.

column (5) again supports the notion that the results are driven by actual news about the adoption of the digital euro rather than central bank communication in general.

4.2.2 Commercial Banks

Next, we shift our focus to commercial banks. Based on the idea that CBDCs might pose disintermediation risks to the traditional banking system, we analyze how stocks of commercial banks react to news about the future adoption of the digital euro. Contrary to our conclusions for the payment sector, we find no significant reaction in bank stocks on days with positive central bank speeches on the digital euro.

Table 4 Panel A reports the results of event study panel regressions using daily stock returns of European commercial banks as dependent variables. The *Positive Sentiment* coefficient of interest varies between -14 basis points in the simplest specification in column (1) and -7 basis points in column (3). None of the coefficients is statistically different from zero. We conclude that there is a tendency for negative coefficients but no robust link between positive central bank speeches on the digital euro and abnormal stock returns of European commercial banks.[16]

In Table 4 Panel B, we use daily stock returns of commercial banks from the United States as dependent variables. There is no clear pattern in abnormal returns on days with positive central bank speeches on the digital euro. The *Positive Sentiment* coefficient varies between -7 basis points in the baseline specification in column (1) and +10 basis points in the factor-specification in column (2). Again, none of the coefficients are statistically significant. The tightest specification in column (4) yields a coefficient that is very close to zero (+2 basis points with a *t*-stat of 0.21).

While there is a clear theoretical link between CBDCs and adverse bank performance, our results somewhat mitigate such concerns for the case of the digital euro. The subdued response of bank stocks to positive news on the adoption of the digital euro indicates that the

[16] Commercial banks offer deposits but also earn income from payment services, both directly as well as via their stake in the European Payment Initiative (the European Payment Initiative is a joint venture that aims to provide retail payment services in Europe and which has built one of the Digital Euro Prototypes, see Chapter 5 for further details). Note that the announcement returns capture a net effect on both the deposit and payment franchise of European banks.

market does not perceive the ongoing CBDC initiative in the Eurozone as a significant threat to the profitability of the banking system. This is in line with the notion that, in practice, any future design of the digital euro can be expected to consider central banks' overriding goal of financial stability. Consequently, the market may deem the proposed risk mitigation mechanisms, such as holding limits for deposits or relatively unattractive remuneration schemes, sufficiently effective.

4.2.3 Overview

In summary, we find that positive central bank speeches on the digital euro are associated with (i) positive abnormal returns for European payment firms, (ii) negative abnormal returns for U.S. payment firms, (iii) somewhat negative but statistically insignificant abnormal returns for European banks, and (iv) no abnormal returns for U.S. banks. The findings are consistent with the strategic-autonomy-in-payments-hypothesis but are difficult to explain through alternative narratives. For example, if the central bank speeches we analyze conveyed general news on the financial industry, the broader economy, or the regulatory environment, all firms in our sample should react synchronously. Similarly, if we were just capturing updates on the outlook of the payment sector, there should be no systematic difference between payment firms from the Eurozone and the United States. Finally, if the speeches were about enhancing the general competitiveness of the Eurozone relative to the United States, stock prices of European payment firms and European banks should act alike rather than moving in opposite directions.

4.2.4 Cumulative Effects

To assess the economic magnitude of our findings, we sum up the *Positive Sentiment* coefficient (β_1) from Equation (1) for all speeches in our sample by firm type.[17] We build on the tightest specification that controls for stock return factors, industry performances, and year-times-quarter fixed effects (equivalent to columns (4) in Table 3) and report results in Figure 3. For payment firms from the Eurozone, abnormal returns related to positive central bank speeches

[17] Conceptually, one could also include *Negative Sentiment* events when summing up announcement returns to capture the net effect of positive and negative communication. However, our sample period includes only 9 *Negative Sentiment* events, almost all of which are at the beginning of our sample period, with non-significant announcement returns.

on the digital euro add up to +30.5% over the sample period. This is in stark contrast to a cumulative abnormal return of -11.6% for payment firms from the United States. The gap in abnormal returns between firms from the Eurozone and the United States starts to emerge in the second half of 2020, corresponding to the release of the first comprehensive report by the ECB regarding the potential issuance of the digital euro (ECB, 2020). Subsequently, the gap noticeably widens, especially after the official launch of the digital euro investigation phase in July 2021 (ECB, 2021). Panel B of Figure 3 focuses on commercial banks. The plot supports the narrative that there is no statistically robust association between positive central bank speeches on the digital euro and commercial banks' stock returns.

We now discuss three angles to understand and interpret the quantitative importance of our findings. First, the 30.5% cumulative abnormal return for the European payment sector translates into an increase in market capitalization of USD 23 billion. In comparison, the -11.6% cumulative abnormal return for the U.S. payment sector implies a USD 127 billion loss in market capitalizations. Taken together, our results, therefore, suggest that the aggregate payment sector market capitalization would suffer from the introduction of the digital euro. This is consistent with the often-cited argument that the digital euro would make payment services less costly for the public and decrease profits for the payment industry (Panetta and Dombrovskis, 2023).

Second, to interpret the negative return for U.S. payment firms economically, one can think about announcement returns as the product of the update in the probability of adoption (PA) and payment firms' exposure at adoption (EAA). Anecdotal evidence suggests that the market's expectations towards the introduction of the digital euro have completely shifted over the course of the sample period (see our discussion in Chapter 2), implying a change in the probability of adoption (PA) of 100% over the entire sample period. We estimate that approximately one quarter of the U.S. payment sectors' revenues originate in the Eurozone.[18] A

[18] The share of revenues stemming from Europe is not generally available for all payment firms in our sample. There are three approaches to estimating this share: First, the Nilson Report – a specialist news outlet covering the global payment industry – estimates that 26% of Visa and Mastercard's combined transaction volume stems from Europe (Nilson, 2022a and 2022b). Second, the average non- U.S. revenues – weighted by the firm's market capitalization – amount to 47% of total revenues in our sample (44% if we conservatively set missing observations to zero). For Visa and Mastercard, approximately half of international revenues stem from Europe. Extrapolating to all firms in our sample gives the share of transaction volume stemming from Europe of 23.5% (22% if we

very simple calculation suggests that an 11.6% decline in market capitalizations corresponds to a reduction in expected European revenues of around 40-50% (EAA = 40-50%). We argue that this range is likely at the upper end of expectations, considering the fixed-cost nature of the payment business and the potential spillover effects that the introduction of a digital euro might bring to revenues in other jurisdictions.[19] We discuss heterogeneity in exposure to the European market in more detail in Section 4.4.

Third, we also compare our results to a major unanticipated regulatory event, the Durbin Amendment. The Durbin Amendment cut debit card fees in the U.S. and was passed as a last-minute unexpected amendment to the Dodd-Frank Act. We find that the Durbin Amendment resulted in cumulative abnormal returns for U.S. payment firms of -5.3% in the week in which the regulation was announced and finalized (May 12 to May 18, 2010).[20] The cumulative abnormal announcement returns for U.S. payment firms in response to positive speeches on the digital euro events are, therefore, roughly twice as high as their cumulative abnormal returns in the context of the Durbin Amendment.

4.3 Robustness Tests

We aim to rule out the possibility that our results merely follow from some idiosyncratic decisions on the empirical design of our study, acknowledging the inherent model risk in empirical research (see e.g., Simonsohn, Simmons and Nelson, 2020; Menkveld et al., 2021; Mitton, 2022). For this, we re-run the panel regressions outlined in Equation (1) using numerous alternative model specifications. In doing so, we modify relevant dimensions of the empirical design and compute the coefficient of interest for all possible design combinations. The considered variations in the empirical design are as follows:

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conservatively set missing observations to zero). Third, when Visa acquired Visa Europe in 2015, Visa provided granular data that show that Europe was responsible for 25% of combined payment volume of Visa (this is a lower bound, because Visa Europe contained the majority, but not all of the European business of Visa at that time, see Visa (2015)).

[19] Due to the inflexible cost structures of many payment firms, a 1% drop in revenues can be expected to reduce profits (and ultimately market capitalizations) by more than 1%. During the COVID-19 pandemic in 2020 for instance, a 4.9% decline in revenues for Visa Inc. led to a 10.0% decline in net income. Further, the introduction of a CBDC in the Eurozone could increase the likelihood of other jurisdictions following suit, introducing their own CBDCs and thereby further limiting the profit potential of payment firms from the United States (see e.g., Sveriges Riksbank, 2023).

[20] Results are available on request. See Kay, Manuszak, and Vojtech (2018) for details on the Durbin amendment, including the Durbin amendment timeline and Reuters (2010) for press coverage on May 18.

(1) *Selection of events* – The events covered by the BIS database likely vary in their influence on market participants' outlook on the adoption of the digital euro. To reduce possible noise, we include specifications in which we exclusively focus on speeches from the "main" European central banks, which we define as the ECB, the Bundesbank, the Banque de France, the Banca d'Italia, and the Banco de España.

(2) *Winsorizing* – To address concerns about the potential impact of outliers on our results, we include specifications involving winsorized stock return data. In addition to the unwinsorized data used for our main analyses, we examine two variations: one with winsorization applied to returns within firms, and another with winsorization applied to returns across firms (at the first and 99th percentile, respectively).

(3) *Sentiment controls* – In our primary analyses, we calculate the *Positive Sentiment* and the *Neutral Sentiment* coefficients based on separate regressions. We now also include specifications in which we simultaneously control for neutral and negative central bank speeches when computing the *Positive Sentiment* coefficients of interest.

(4) *Firm classifications* – Our main results build upon the firm classifications outlined in Section 3.1, including our newly proposed approach for identifying payment firms. As our approach allows variations in firm classifications over time, firms representing 10% of the payment sector market capitalization as of year-end 2022 undergo at least one classification switch during the event study sample period. To rule out that these switches in classifications affect our results, we examine specifications in which firm classifications are set as of 2015 (i.e., the year before there were any central bank speeches on the digital euro). For firms entering the sample after 2015, we fix their classifications as of the time they first appear in the sample. In addition, we run tests in which we classify commercial banks and payment firms based on their header GICS codes[21].

(5) *Factor models* – In addition to modeling expected stock returns with the market model and the 6-factor model, we also run regressions based on the traditional 3-factor model (Fama and French, 1992).

[21] For the respective specifications, we define commercial banks as firms with a GICS code that starts with '4010' and payment firms as those with a GICS code of '40201060'.

(6) *Industry controls* – In our primary analyses, we use region-specific industry indices as control variables (Euro Stoxx subindices for the Eurozone regressions and S&P 500 subindices for the U.S. regressions). We now also consider specifications in which we replace the region-specific indices with the equivalent global subindices from the MSCI World index.

(7) *Time fixed effects* – We vary the choice of fixed effects and consider both longer and shorter reference periods than the year-times-quarter fixed effects used in the main analyses. Specifically, we run additional specifications in which we control for (i) year-fixed effects, (ii) year-times-month fixed effects, and (iii) no fixed effects.

(8) *Earnings announcements* – To mitigate concerns regarding confounding events, we collect data from *Refinitiv* on historical earnings announcements in the payment sector and control for such announcements via dummy variables. The considered announcements include 253 observations related to the five largest payment firms in the United States and the Eurozone, respectively.

The different empirical dimensions add up to 2 x 3 x 2 x 3 x 3 x 3 x 4 x 2 = 2,592 unique regression specifications for each of the four different types of firms under investigation. Figure 4 Panel A reports the respective results for payment firms. For firms from the Eurozone, the *Positive Sentiment* coefficient of interest varies between +29 basis points and +68 basis points, with a mean of +49 basis points, a median of +48 basis points, and an interquartile range from +45 basis points to +52 basis points. The *Positive Sentiment* coefficient for U.S. payment firms, on the other hand, varies between -26 basis points and -9 basis points, with a mean of -18 basis points, a median of -18 basis points, and an interquartile range from -20 basis points to -16 basis points.

Figure 4 Panel B presents the results for commercial banks. Contrary to the payment firm-specific findings, there is a noticeable overlap in the distributions of the relevant regression coefficients for European and American commercial banks. For commercial banks from the Eurozone, the *Positive Sentiment* coefficient varies between -29 basis points and +0 basis points, with a mean of -15 basis points, a median of -15 basis points, and an interquartile range from -19 basis points to -11 basis points. For commercial banks from the United States, the *Positive Sentiment* coefficient varies between -17 basis points and +18 basis points, with a mean of +2

basis points, a median of +2 basis points, and an interquartile range from -3 basis points to +8 basis points.

Overall, the robustness tests support our earlier conclusions that positive central bank communication on the digital euro has (i) significant opposing effects on the valuations of payment firms from the Eurozone and the United States, and (ii) no systematic, statistically robust effect on the valuations of commercial banks.

4.4 Heterogeneity Across Payment Firms

For the event study period from 2016 to 2022, our sample contains 74 distinct payment firms from both the Eurozone and the United States. These firms have heterogeneous business models and perform various activities along the payment value chain. It can thus be expected that news on the future adoption of the digital euro should have heterogeneous effects on firms' valuations. We test this conjecture by studying more closely how specific firms react to positive central bank speeches on the digital euro.

First, we focus on the U.S. payment sector. Following the narrative that a central theme of the digital euro is strategic autonomy in payments, we expect stronger announcement effects for firms active in the Eurozone. Within the sample of payment firms from the United States, those with an extended international profile should hence be more affected than those with purely domestic activities. To measure firms' international exposure, we use geographic sales data from *FactSet*. Focusing on the extensive margin, we split the sample based on whether or not a given U.S. payment firm had positive non-U.S. sales as of 2015 (i.e., the year before there were any central bank speeches on the digital euro). Unfortunately, firms typically do not explicitly disclose European sales data, so that we need to rely on non-U.S. sales as a proxy for the exposure of U.S. payment firms to the introduction of the digital euro. In this manner, we identify 24 internationally active firms and 13 firms with a purely domestic focus (we lack geographic sales data on the remaining firms and thus do not consider them for the following analysis). Next, we separately run the event study regressions from Equation (1) for each of the two subsamples. The results in columns (1) and (2) of Table 5 support our hypothesis of a heterogeneous treatment effect. For internationally active U.S. payment firms, positive speeches on the digital euro are associated with negative abnormal returns of -21 basis points

(*t* statistic = -2.04). Stocks of payment firms whose activities are bound to the U.S., on the other hand, do not react to news on the digital euro (coefficient = 0.005, *t*-statistic = 0.47).[22]

In addition to the geographic dimension, we consider heterogeneity across payment firms' business models. For this, we distinguish between 'pure-play' payment firms and 'diversified' payment firms. As indicated in Table 2, interest income tends to play a smaller role for payment firms than for other financial intermediaries. As such, we regard higher shares of interest income relative to revenues as an indicator for more diversified business activities. Specifically, we classify firms as 'pure-play' payment firms if they (i) fulfill our standard definition of a payment firm (Section 3.1) and (ii) have a 'Net Interest Income / Net Revenue'-ratio of at most 1%.[23] Correspondingly, we classify firms as 'diversified' payment firms if they (i) fulfill our standard definition of a payment firm and (ii) have a 'Net Interest Income / Net Revenue'-ratio of more than 1%.[24] Consistent with the notion that the digital euro mainly revolves around the means-of-payment function, column (3) of Table 5 reports a statistically significant *Positive Sentiment* coefficient of -20 basis points for the subsample of undiversified ('pure-play') payment firms. In contrast to this, stocks of payment firms with more diversified

[22] Note that the coefficient for internationally active U.S. payment firms is very close to our estimate for the entire sample of U.S. payment firms (Panel B of Table 3). This is not surprising, as we report value-weighted regressions and the internationally active U.S. payment firms also tend to be the largest payment firms, with an average aggregate market capitalization of more than USD 854 billion. The main learning from this heterogeneity test is the finding that stocks of payment firms bound to the U.S. do not react, ruling out that our results are simply driven by general news on the outlook of the U.S. payment market.

[23] For certain firm-years in our sample, the required information to compute firms' 'Net Interest Income / Net Revenue' ratio is missing in Compustat. We deal with missing information in the following way: (i) If interest income (Compustat: *idit*) is available but interest expenses (Compustat: *xint*) are missing for a given firm-year, we set the firm's interest expenses to zero; (ii) if interest income is missing for a given firm-year, we classify the firm as 'pure-play' payment firm. Condition (i) implies that we err on the conservative side and increase the likelihood for firms with missing interest expense information to be classified as non-pure-play payment firms. Condition (ii) builds on a manual review of selected annual reports of payment firms based on which we conclude that missing data items in Compustat tend to relate to information that is not material for the respective firms (i.e., firms that do not explicitly disclose interest income in their annual reports generally have other, more important, sources of revenues). 95% of U.S. payment firms have a 'Net Interest Income / Net Revenue' ratio of 1% or less; that is, their net interest income is negligible. In contrast to this, only 0.8% of U.S. banks have a 'Net Interest Income / Net Revenue' ratio of 1% or less. Two larger payment firms have ratios higher than 1% and are therefore not defined as 'pure-play' payment firms: American Express (18%) and Discover (76%). Column (4) of Table 5 is, therefore, essentially a value-weighted result for American Express and Discover.

[24] 95% of U.S. payment firms have a 'Net Interest Income / Net Revenue' ratio of 1% or less; that is, their net interest income is negligible. In contrast to this, only 0.8% of U.S. banks have a 'Net Interest Income / Net Revenue' ratio of 1% or less. Two larger payment firms have ratios higher than 1% and are therefore not defined as 'pure-play' payment firms: American Express (18%) and Discover (76%). Column (4) of Table 5 is, therefore, essentially a value-weighted result for American Express and Discover.

activities react less strongly to positive central bank speeches on the digital euro (-11 basis points, *t*-statistic = 0.77).

Due to the smaller number of listed payment firms from the Eurozone, we lack the statistical power to conduct tests that directly correspond to the U.S.-based heterogeneity analyses presented in Table 5. Instead, we report the event study coefficients of the individual European payment firms in our sample (Table 6). We find positive coefficients for all four major European payment firms (Adyen, Nexi, Worldline, Edenred), with two of the four regressions yielding statistically significant results. The coefficients for Wirecard and Ingenico are negative and insignificant. Ingenico produces hardware terminals and is, therefore, unlikely to be significantly affected by the digital euro. Wirecard was involved in a massive accounting scandal during our sample period and filed for bankruptcy in 2020 (McCrum, 2020).

Finally, in Figure 5, we plot the firm-level coefficients of the largest five European payment firms next to those of the largest ten U.S. payment firms. The pattern is striking: four out of the five highest coefficients belong to payment firms from the Eurozone, or put differently, nine out of the ten lowest coefficients belong to payment firms from the United States. Except for Wirecard, all Eurozone coefficients are positive, while, except for Discover, all U.S. coefficients are negative. U.S. payment firms tend to follow more heterogenous business models, ranging from networks (Visa, Mastercard, American Express, Discover), facilitators (Paypal, Block/Square) to processors (Fiserv, FIS, Global Payments), while the major European payment firms are processors (Adyen, Worldline, Nexi). Announcement returns for U.S. payment processors tend to be even slightly more negative than the average U.S. payment firm announcement return, suggesting we are not picking up differences in business models, but a U.S.-versus-Europe difference in announcement returns.

4.5 Heterogeneity Across Speeches

The prior section explored heterogeneity across payment firms. This section will focus on heterogeneity across speeches. We analyze heterogeneity across speeches in a two-step process. First, we exclude speeches that only marginally relate to the digital euro. Second, we exclude speeches that do not provide (positive) news on the digital euro. The second step involves building a chronological database of digital euro news from speeches and comparing the

statements on the digital euro in a particular speech to the cumulative news from prior speeches. The second step thus aims to assess whether a given speech could have plausibly affected people's priors on the future adoption of the digital euro. To make the classification process as transparent as possible, we provide details in Internet Appendix Table B.1 and discuss specific examples in the following paragraphs. The first step, excluding speeches that only marginally relate to the digital euro, can be broken down into two sub-steps:

(i) We exclude all speeches that have a generic title. For example, the BIS database includes a speech from ECB President Christine Lagarde from Feb 11, 2020 that is titled "Debate about the Annual Report" (https://www.bis.org/review/r200211f.htm). Such speeches are unlikely to provide major updates on the digital euro.

(ii) We exclude all speeches that are overly generic in their content. Some speeches in the BIS database discuss the digital euro only very briefly, although this is not immediately revealed by their titles. For example, there is a seven-page speech from Banque de France Governor François Villeroy de Galhau from May 16, 2022 titled "Multipolarity and the role of the euro in the International Financial System" (https://www.bis.org/review/r220516a.pdf), which mentions CBDC only in a single paragraph on the very last page.

These two criteria (generic title, generic content) are easy to judge. Criterion (i) excludes eight speeches, criterion (ii) an additional four speeches – leaving us with 57 speeches out of the baseline sample of 69 speeches with a positive stance on the digital euro. Table 7 reports event study results when excluding the identified generic speeches from the set of considered observations. Our results are clearly not driven by these generic speeches, and results even get somewhat stronger when excluding generic speeches (columns (1) to (3) in Panel A and Panel B of Table 7).

In the second step, we exclude speeches that do not provide any (positive) update on the digital euro. It is important to understand that "no news" is not the same as "no positive stance". Some of the speeches in the BIS database have a very positive stance on the digital euro in general but only convey messages that have already been communicated in prior speeches. One example is Christine Lagarde's speech from Feb 14, 2022, which has a positive stance but conveys no information over and above prior speeches (https://www.bis.org/review/r220215a.htm). Some speeches can also contain news, but the news may be minor or even

negative. For example, a speech from the Deputy Governor of the Banque de France, Denis Beau, from April 15, 2022 contains, among others, the information that "A final decision on whether to launch a digital euro will be taken in the final quarter of 2023." Prior speeches already communicated that a final decision will be taken in 2023, so adding "final quarter" is, if at all, a negative update on the timeline of the digital euro.

The "no positive news"-criterion requires a chronological tabulation of news from every speech. We read the transcripts of all positive-news speeches in chronological order and report the news content of each of these speeches in Internet Appendix Table B.1, together with links to all speech transcripts for easy accessibility. Based on the assessment of the speeches' news content, we exclude another 23 speeches, leaving us with a remaining set of 34 speeches – half of the original sample of 69 speeches. Results are reported in column (4) of Table 7. Announcement returns are economically and statistically stronger than in our baseline specifications (+70 basis points for European payment firms, -27 basis points for U.S. payment firms). The 34 speeches explain almost 80% of the observed abnormal announcement returns for the European and U.S. payment firms.

Finally, in column (5) of Table 7 we focus on 12 speeches that we label 'Top Speeches'. These speeches convey significant and positive news not communicated in any of the prior speeches. In contrast to the previous selection exercises, identifying 'Top Speeches' involves a more subjective assessment of the speeches' importance. Examples of 'Top Speeches' include François Villeroy de Galhau's speech in 2019, which sets out key elements of the digital euro (European payment solution, public/private partnership for distribution), and a speech from ECB Board member Fabio Panetta at the European Parliament, that, among others, unveils the legal tender strategy to achieve network effects and strongly pushes the strategic-autonomy-narrative to lawmakers. Relative to our baseline results, these 12 'Top Speeches' are associated with significantly stronger announcement returns (+121 basis points for European payment firms, -39 basis points for U.S. payment firms, see column (5) in Table 7).

Taken together, we conclude that abnormal announcement returns are concentrated around speeches that are non-generic in nature and that plausibly update investors' priors. A set of roughly half of the positive-stance speeches explains almost 80% of the cumulative abnormal announcement returns. For these speeches, U.S. payment firms exhibit negative abnormal

returns, while European payment firms exhibit positive abnormal returns. This result is inconsistent with general news conveyed about the economy or the payment sector; it is consistent with a geopolitical dimension of CBDCs: strategic autonomy in payments.

5. Supporting Evidence from Policymakers' Actions and Communication

In this section, we provide supporting evidence that the digital euro is primarily focused on the means-of-payment function, with the aim of providing strategic autonomy in payments.

5.1 Digital Euro Market Advisory Group

On October 25, 2021, the ECB announced the creation of a Digital Euro Market Advisory Group (DE-MAG). The group consists of 30 business professionals whose task is to advise the Eurosystem on (i) the design and distribution of a potential digital euro, and (ii) the question of how the digital euro could add value.[25]

Appendix Table A.1 lists the members of the task force. Out of the 30 members, 29 are from firms based in Europe. Despite U.S. payment firms playing a dominant role in the current European payment architecture, the only U.S.-based firm represented in the DE-MAG is Stripe (a payment firm with Irish founders and dual headquarters in San Francisco and Dublin). The appointment process for the DE-MAG is not transparent, and we therefore cannot establish with certainty whether the absence of major U.S. payment firms is due to their unwillingness to participate, or due to the ECB's preference for European firms. However, it is not clear why any major payment firm would refuse to participate. Media coverage from specialized payment outlets suggests the latter explanation, with the ECB shunning Visa, Mastercard, and PayPal.[26]

5.2 Prototyping

In September 2022, the ECB selected five companies to develop prototype user interfaces for the digital euro. These companies were selected after a call for expression of interest that stated

[25] See www.ecb.europa.eu/paym/digital_euro/investigation/shared/files/digital_euro_mandate_mag.pdf

[26] See „ECB Shuns Visa, Mastercard, PayPal for Digital Euro Advisory Panel" (PYMNTS, October 25, 2021, available via www.pymnts.com/cbdc/2021/ecb-shuns-visa-mastercard-paypal-digital-euro-advisory-panel) and "ECB advisory group for the digital euro excludes US payment firms" (Ledger Insights, October 25, 2021, available via www.ledgerinsights.com/ecb-advisory-group-for-the-digital-euro-excludes-us-payment-firms).

"The ECB will give preference to providers that are located in the European Economic Area (EEA)."[27] Importantly, other calls for expression of interest by the ECB do not include such preference.[28] Four out of the five companies selected were European (Worldline, EPI[29], Nexi, CaixaBank), with only one company being from the U.S. (Amazon for the e-commerce use case). All four successful European firms highlighted their participation in the prototyping exercise prominently in their annual reports. This provides anecdotal evidence that the prototyping exercise was of significant importance for these firms.[30]

5.3 ECB and European Commission Press Releases

The European Commission's draft regulation on the digital euro (June 2023), as well as the announcement of the start of the preparation phase (October 2023), were accompanied by official press announcements. ECB President Christine Lagarde highlighted the means-of-payment function, stating "*The design envisages the digital euro as a digital form of cash that could be used for all digital payments.*" ECB Board member Fabio Panetta was quoted saying "*A digital euro would increase the efficiency of European payments and contribute to Europe's strategic autonomy.*" The EU commissioner responsible for the draft regulation on the digital euro highlighted the ability for digital payments and financial inclusion, before stating "*Europe's current payment systems are national or international – we don't have truly European options, and are overly reliant on companies such as Visa, Mastercard, or PayPal*" (McGuinness, 2023).

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[27] See www.ecb.europa.eu/paym/digital_euro/investigation/profuse/shared/files/dedocs/ecb.dedocs220428.en.pdf and www.ecb.europa.eu/paym/digital_euro/investigation/profuse/shared/files/dedocs/ecb.dedocs220428_annex.en.pdf.

[28] For example, see this call for work on new technologies for settlement of wholesale financial transactions in central bank money: www.ecb.europa.eu/paym/intro/news/ecb.mipnews231213_annex1.en.pdf.

[29] The EPI – the European Payment Initiative – is a joint venture headquartered in Brussels and supported by a large group of European banks and payment firms. It was founded in December 2020 and had slightly more than 20 employees as of 2022. The ECB required any company to have at least 20 employees to be allowed to participate in the prototyping exercise, had this limit been slightly higher, EPI would not have qualified.

[30] Both Nexi and Worldline mention their participation in the letter to shareholders at the very beginning of their Annual Reports. CaixaBank mentions the participation in the overview "Significant events in the year" as one of 32 significant events for the year 2022. EPI is a private company and thus does not provide a publicly available annual report. EPI has a "Company News" section where it covers the participation as one of seven events for that year.

5.4 Central Bank Speeches

The press releases between June 2023 and October 2023 highlight focal arguments of the ECB and the European Commission at the time when the introduction of a digital euro was (de facto) announced. A time series pattern of the key topics discussed by the ECB can be deduced from a textual analysis of speeches. Using the sample of speeches used in Chapter 4, we study how frequently these speeches address specific topics in the context of the digital euro. Specifically, we use ChatGPT to analyze speech transcripts collected by the BIS (details in Appendix B). Appendix B.1 illustrates the results of the analysis. As to be expected, central bank communication regularly focuses on topics such as 'monetary policy' and 'financial stability'. More surprisingly, we observe a strong increase over time in the share of speeches that address the topic of 'strategic autonomy'. While not a single central bank speech associated the digital euro with strategic autonomy until 2018, almost half of all speeches in 2022 refer to the strategic-autonomy-motive. The findings are consistent with the rising importance of geopolitical considerations in the context of the digital euro.

5.5 Communication by Private-Sector Firms and Merchant Associations

E-Commerce Europe, an industry association representing more than 150,000 merchants in the European Union, actively supports the digital euro in its statements. A press release from March 2024 ("Digital Euro: Merchants support a fast, innovative, and low-cost pan-European payment method") states that "*The digital euro has the potential to transform European payments – increasing efficiency, promoting innovation, and placing Europe at the forefront of payment technology* ". The press release further states *"merchants are the business end-users of the EU payment ecosystem and are currently limited in their ability to negotiate fair terms"*. Therefore, *"merchants stand to benefit from lower costs"* associated with the digital euro. Specifically, Merchants expect not to have to pay an interchange fee for digital euro transactions, and to benefit from a low fixed per-transaction fee.[31]

Contrary to these affirmative remarks, U.S. payment firms typically express skepticism and oppose the digital euro. Mastercard, for example, writes in its public feedback to the digital

[31] See https://ecommerce-europe.eu/wp-content/uploads/2024/03/2024-03-11-digital-euro-joint-statement-merchant-payments-coalition-europe.pdf.

euro project: *"We are particularly concerned that the proposal to establish the digital euro has gone beyond its stated objective of providing individuals and businesses with a digital form of central bank money. Instead, the proposal seeks to create a duplicative, non-market led payment system that calls into question the European Union's (EU) established approach to an open market economy with free competition*".[32]

European payment firms generally see a business opportunity and support the digital euro. For example, French company Wordline states in its 2022 annual report: *"As a recognised payment leader, we are committed to playing an increasingly visible role at the pan-European level as we support at different levels major developments, such as the European Payments Initiative or the Digital Euro."*[33]

Taken together, private-sector firm communication provides anecdotal evidence that: (i) merchant associations support the digital euro because they expect lower fees, (ii) U.S. payment firms oppose the digital euro because they identify it as a business risk, (iii) European payment firms support the digital euro because they see a business opportunity.

Overall, the actions and communications of policymakers and payment firms point to a strategic-autonomy-in-payments-motivation behind the digital euro. The evidence is consistent with the pattern of announcement returns documented in Chapter 4 (negative announcement returns for U.S. payment firms, positive announcement returns for European payment firms, and no effect for banks). The findings suggest a novel geopolitical dimension of CBDCs: enhanced autonomy in payments.

6. Conclusion

In this paper, we highlight the medium-of-exchange function of CBDCs and study their effects on the payment industry. Stock prices of U.S. payment firms *decrease*, while stock prices of European payment firms *increase* in response to positive announcements on the digital euro. Bank stocks do not react. Our results are consistent with the notion that the development of the

[32] See https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13392-A-digital-euro-for-the-EU/F3436030_en.

[33] See https://investors.worldline.com/content/dam/investors-worldline-com/assets/documents/universal-registration-document/wdl2022-urd-en-mel-23-05-12.pdf.

digital euro is driven by a desire for strategic autonomy in payments, pointing to a novel geopolitical dimension of CBDCs.

Our results have several implications for future research on CBDCs and beyond. First, the digital euro is primarily designed as a means of payment. Its primary impact will, therefore, not be felt by deposit-taking banks, but rather by those financial intermediaries that provide payment services. Second, our results imply a novel motive for the issuance of CBDCs – namely policymakers' desire to build the capacity to act autonomously in strategically important policy areas ("strategic autonomy"). The implications of such a strategic autonomy motive have not been analyzed so far, neither for the issuance of CBDC nor for other policy areas. Our findings call for the integration of the strategic autonomy motive into existing models of CBDCs. This is a challenging task because the advantages and disadvantages of "strategic autonomy" are not necessarily straightforward to capture.

CBDCs can be implemented with different design choices, and our results should be interpreted within the context of the digital euro design (retail CBDC, maximum holding limit, zero interest rate, legislative backing with a requirement to accept the digital euro, distribution via payment service providers). Future research might investigate how other CBDC designs affect payment firms as well as how they affect the geopolitical dimension of CBDCs.

Finally, this paper contributes to the literature by developing a method to classify firms as payment firms based on the combination of a firm's SIC code and certain keywords in its business description. We document the rise of payment firms over the past two decades and highlight differences in business models between payment firms and commercial banks – supporting our argument that payment firms constitute a distinct category within the financial sector. We hope that our classification of payment firms will be useful to academics in future research.

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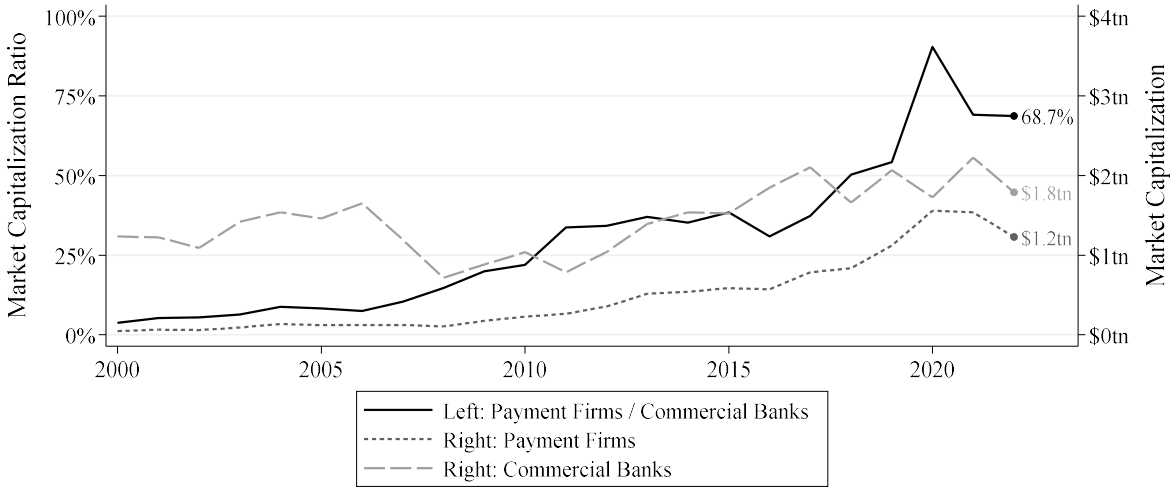
Figures

Figure 1: Market Capitalizations of Payment Firms and Commercial Banks Over Time

This figure illustrates the market capitalizations of payment firms and commercial banks from 2000 to 2022. The solid black line represents the ratio between the overall market capitalization of payment firms and that of commercial banks (depicted on the left-hand-side y-axis). The dashed grey lines represent the market capitalizations of payment firms and commercial banks in USD trillion (depicted on the right-hand-side y-axis). Panel A refers to firms from the U.S. and Panel B refers to firms from the Eurozone. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. We define commercial banks as listed firms with a SIC code of '60'. Market capitalizations are based on end-of-calendar-year values from *Compustat*.

Panel A: U.S. Firms



Panel B: Eurozone Firms

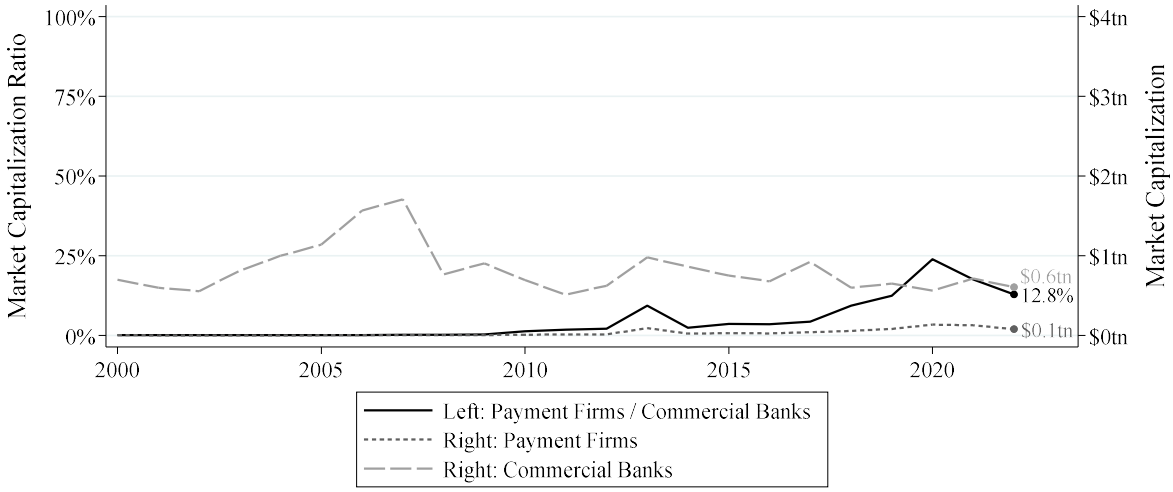


Figure 2: Timeline – Central Bank Speeches on the Digital Euro

This figure illustrates the timeline of central bank speeches on the digital euro based on Auer, Cornelli, and Frost (2020). It plots the sentiment (positive/negative/neutral) of each speech against the day on which the speech was given. Events are defined as days on which there is a speech on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The dashed line represents the cumulative trend in speech sentiment over time. The trend is defined as the mean sentiment from all observed speeches leading up to a particular day. The sample period is from 2016 to 2022.

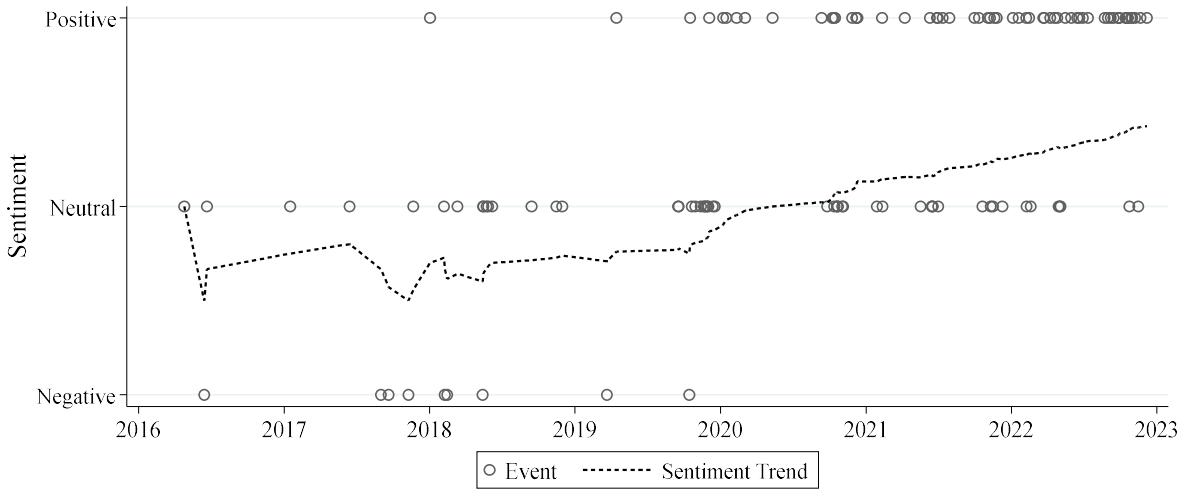
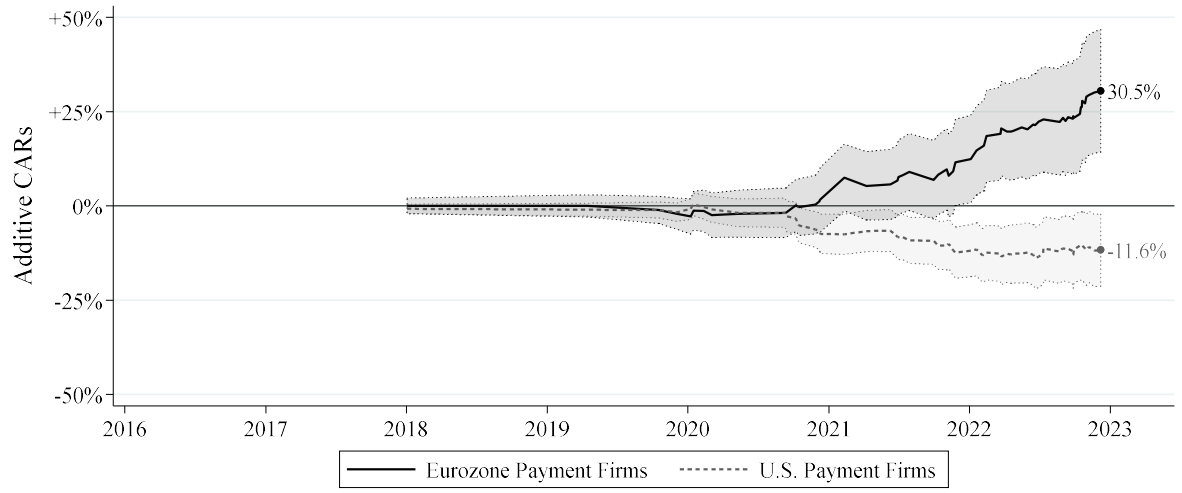


Figure 3: Event Studies – Positive Speeches on the Digital Euro and Cumulative Abnormal Returns

This figure illustrates cumulative abnormal returns of regional stock indices of payment firms (Panel A) and commercial banks (Panel B) across days with positive central bank communication on the digital euro. We compute cumulative abnormal returns based on Equation (1) by summing up the *Positive Sentiment* coefficient (β_1) over time. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. We define commercial banks as listed firms with a SIC code of '60'. To identify events, we rely on the BIS database from Auer, Cornelli, and Frost (2020), focusing on days on which there is positive communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. Shaded areas indicate 90% confidence bands. The sample period is from 2016 to 2022.

Panel A: Payment Firms



Panel B: Commercial Banks

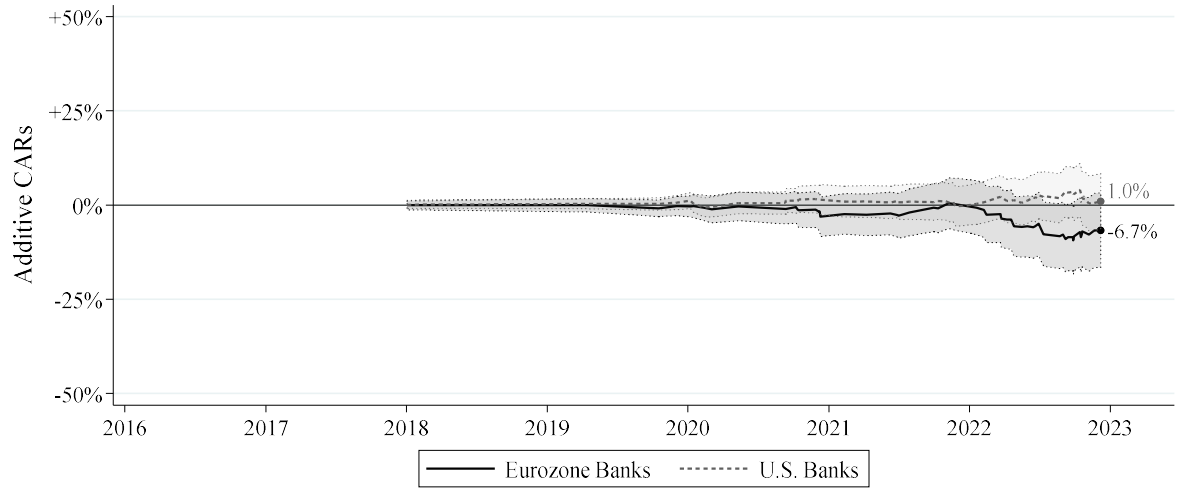
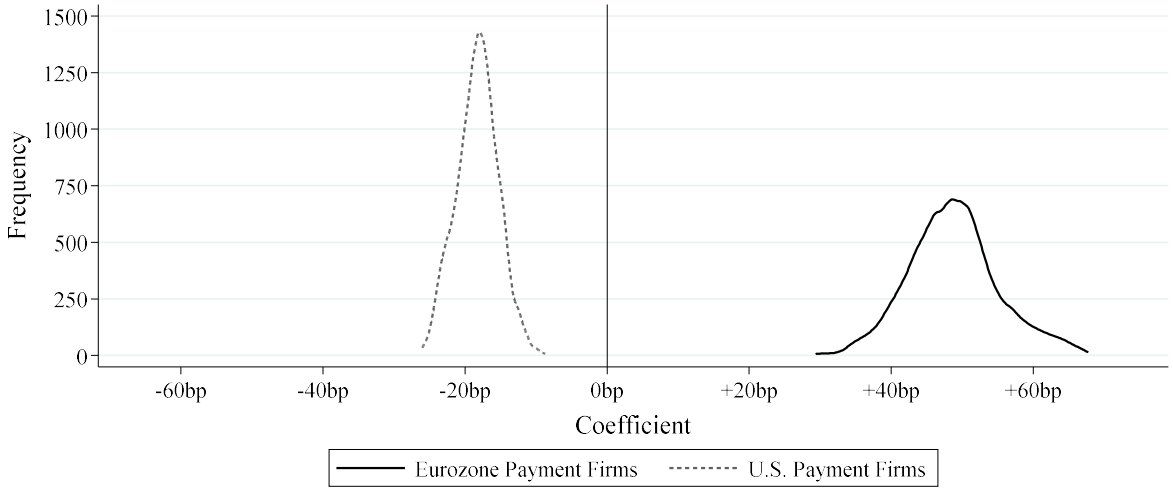


Figure 4: Event Study Robustness Tests – Positive Speeches on the Digital Euro and Abnormal Returns

This figure illustrates the distribution of the *Positive Sentiment* coefficients (β_2) for 2,592 different event study panel regressions (per firm type) of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. In Panel A, the dependent variables are daily stock returns of payment firms. In Panel B, the dependent variables are daily stock returns of commercial banks. The plotted regression specifications include all possible combinations with respect to the following dimensions: events *[all; main central banks]*, return winsorizing *[no; within firms (1st, 99th); across firms (1st, 99th)]*, sentiment controls *[positive; positive/neutral/negative]*, firm classification *[SIC and business description (dynamic); SIC and business description (as of 2015); GICS]*, factor models *[market; 3 factors; 6 factors]*, industry controls *[no; local; global]*, time fixed effects *[no; year; year-quarter; year-month]*, and earnings announcement controls *[no; yes]*. The sample period is from 2016 to 2022.

Panel A: Payment Firms



Panel B: Commercial Banks

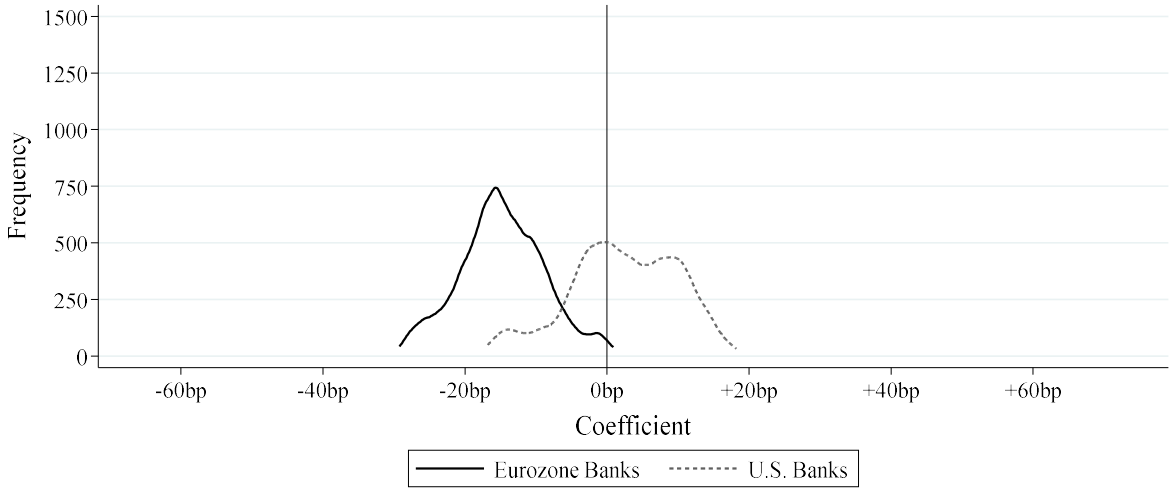
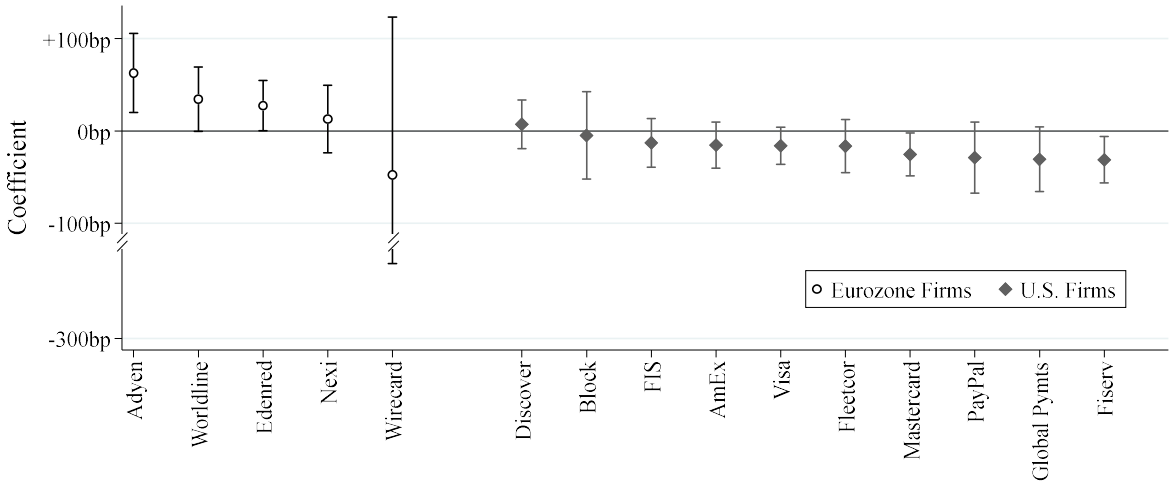


Figure 5: Digital Euro Event Studies – Heterogeneity Across Payment Firms

This figure illustrates the *Positive Sentiment* coefficients (β_2) from separate firm-level event study regressions of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The dependent variables are daily stock returns of the five largest payment firms from the Eurozone and the ten largest payment firms from the U.S. (based on firms' average end-of-year market capitalizations). We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. In all regressions, we control for common stock return factors, abnormal returns of different industry indices, and year-times-quarter fixed effects. Capped spikes indicate 90% confidence bands. The sample period is from 2016 to 2022.



Tables

Table 1: Largest Payment Firms and Commercial Banks by Region

This table lists the largest payment firms and commercial banks from the U.S. and the Eurozone. The ranking is based on firms' market capitalizations as of year-end 2022. Market capitalizations are from *Compustat*. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. We define commercial banks as listed firms with a SIC code of '60'.

	United States		**Eurozone**	
Rank	**Payment Firms**	**Commercial Banks**	**Payment Firms**	**Commercial Banks**
1	Visa *$430bn*	JPMorgan Chase *$393bn*	Adyen *$43bn*	BNP Paribas *$70bn*
2	Mastercard *$332bn*	Bank of America *$265bn*	Edenred *$14bn*	Banco Santander *$50bn*
3	American Express *$110bn*	Wells Fargo *$158bn*	Worldline *$11bn*	ING *$45bn*
4	PayPal *$81bn*	Citigroup *$88bn*	Nexi *$10bn*	Intesa Sanpaolo *$42bn*
5	Fiserv *$64bn*	U.S. Bancorp *$67bn*	Ease2pay *$0bn*	Nordea *$39bn*
6	FIS *$40bn*	PNC *$63bn*	Wirecard *$0bn*	BBVA *$36bn*
7	Block/Square *$38bn*	Truist *$57bn*		Credit Agricole *$32bn*
8	Discover *$26bn*	BNYM *$37bn*		CaixaBank *$32bn*
9	Global Payments *$26bn*	State Street *$27bn*		UniCredit *$27bn*
10	Fleetcor *$13bn*	M&T Bank *$25bn*		KBC *$27bn*

Table 2: Financial Statistics – Payments Firms vs. Commercial Banks

This table summarizes key financial metrics for payment firms and commercial banks in the U.S. and the Eurozone. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. We define commercial banks as listed firms with a SIC code of '60'. The sample period is from 2000 to 2022. *Firms* is the total number of distinct firms. For all other variables, we aggregate the data across two dimensions: First, we aggregate the data on an annual level for payment firms and commercial banks, respectively. Next, we take simple averages across the annually aggregated data to compute summary statistics by firm types. *Market Cap* is the average aggregate market capitalization (in USD million). *Equity* is the average aggregate book equity value (in USD million). *Assets* is the average aggregate asset value (in USD million). Equity is the average aggregate book equity value. *Net Revenue* is the average aggregate net revenue, i.e., total revenue minus interest expenses (in USD million). Employees is the average aggregate number of employees (in thousand). *ROA* is the average aggregate return on assets (in %). *ROE* is the average aggregate return on equity (in %). *Net Revenue Growth* is the aggregate value-weighted growth in net revenues (in %). *Net Debt / EBIT* is the average aggregate net debt to EBIT ratio. *Equity / Capital* is the average aggregate ratio of book equity to total capital (in %). *Net Interest Inc. / Net Rev.* is the average aggregate ratio of net interest income to net revenue (in %). The data is from *Compustat*.

	United States		**Eurozone**	
	Payment Firms	**Commercial Banks**	**Payment Firms**	**Commercial Banks**
Count				
Firms (#)	111	1,218	9	236
Size				
Market Cap ($m)	485,799	1,441,038	30,427	794,752
Assets ($m)	344,190	11,847,464	26,030	24,538,064
Equity ($m)	85,403	1,076,897	6,330	1,121,212
Net Revenue ($m)	90,359	513,711	9,531	551,219
Employees ('000)	197	1,732	20	1,922
Profitability				
ROA (%)	4.3	0.9	2.3	0.2
ROE (%)	16.1	9.8	10.5	6.3
Growth				
Net Revenue Growth (%)	9.0	5.4	18.9	2.1
Leverage				
Net Debt / EBIT	1.6	10.0	2.0	9.7
Equity / Capital (%)	27.7	9.0	30.3	4.4
Business Model				
Net Interest Inc. / Net Rev. (%)	6.9	55.1	0.1	51.1

Table 3: Event Studies – Communication on the Digital Euro and Stock Returns of Payment Firms

This table reports the results from event study panel regressions of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The sample period is from 2016 to 2022. In Panel A, the dependent variables are daily stock returns of Eurozone payment firms. In Panel B, the dependent variables are daily stock returns of U.S. payment firms. Observations are weighted by firms' previous day's market capitalization. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. *Positive Sentiment* and *Neutral Sentiment* are dummy variables. They respectively take a value of one if there is an event with a positive or neutral sentiment towards the digital euro on a given day and otherwise take a value of zero. *Market* is the daily return of the market in excess of the risk-free rate. Column (1) is the baseline specification. In column (2), we control for common stock return factors (*Small-Minus-Big*, *High-Minus-Low*, *Conservative-Minus-Aggressive*, *Robust-Minus-Weak*, and *Momentum*; all taken from Kenneth French's website). In column (3), we additionally control for abnormal returns of different industry indices. In column (4), we add year-times-quarter fixed effects. Column (5) is a placebo test in which we consider neutral sentiment events. The two rows at the bottom of each table indicate the number of considered speeches by sentiment in each regression specification. In all specifications, we cluster standard errors at the date level. T-statistics are reported in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively.

Panel A: Eurozone Payment Firms

	(1) **Baseline**	**(2)** **Factors**	**(3)** **Industry Controls**	**(4)** **Fixed Effects**	**(5)** **Placebo**
Positive Sentiment	0.0043**	0.0044**	0.0047***	0.0052***	
	(2.28)	(2.41)	(2.90)	(2.99)	
Neutral Sentiment					0.0007
					(0.57)
Market	1.0420***	1.0044***	0.9565***	0.9661***	0.9689***
	(24.67)	(23.90)	(28.05)	(28.23)	(28.28)
Constant	0.0002	0.0002	0.0004	-0.0002	-0.0002
	(0.53)	(0.57)	(1.37)	(-0.14)	(-0.13)
Observations	11,004	11,004	10,895	10,895	10,895
Adjusted R-squared	0.2111	0.2721	0.3304	0.3320	0.3308
Stock Return Factors	No	Yes	Yes	Yes	Yes
Industry Controls	No	No	Yes	Yes	Yes
Year x Quarter FE	No	No	No	Yes	Yes
# Positive Speeches	69	69	69	69	-
# Neutral Speeches	-	-	-	-	58

Panel B: U.S. Payment Firms

	(1) Baseline	(2) Factors	(3) Industry Controls	(4) Fixed Effects	(5) Placebo
Positive Sentiment	-0.0019*	-0.0018*	-0.0020**	-0.0019**	
	(-1.84)	(-1.78)	(-2.10)	(-2.03)	
Neutral Sentiment					0.0011
					(0.93)
Market	1.1774***	1.1575***	1.1545***	1.1560***	1.1552***
	(43.62)	(38.54)	(43.95)	(43.21)	(43.13)
Constant	0.0002	0.0002	0.0002	-0.0001	-0.0001
	(0.95)	(1.30)	(1.41)	(-0.06)	(-0.06)
Observations	62,049	62,049	62,049	62,049	62,049
Adjusted R-squared	0.5004	0.5058	0.5149	0.5160	0.5158
Stock Return Factors	No	Yes	Yes	Yes	Yes
Industry Controls	No	No	Yes	Yes	Yes
Year x Quarter FE	No	No	No	Yes	Yes
# Positive Speeches	69	69	69	69	-
# Neutral Speeches	-	-	-	-	58

Table 4: Event Studies – Communication on the Digital Euro and Stock Returns of Commercial Banks

This table reports the results from event study panel regressions of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The sample period is from 2016 to 2022. In Panel A, the dependent variables are daily stock returns of Eurozone commercial banks. In Panel B, the dependent variables are daily stock returns of U.S. commercial banks. Observations are weighted by firms' previous day's market capitalization. We define commercial banks as listed firms with a SIC code of '60'. *Positive Sentiment* and *Neutral Sentiment* are dummy variables. They respectively take a value of one if there is an event with a positive or neutral sentiment towards the digital euro on a given day and otherwise take a value of zero. *Market* is the daily return of the market in excess of the risk-free rate. Column (1) is the baseline specification. In column (2), we control for common stock return factors (*Small-Minus-Big*, *High-Minus-Low*, *Conservative-Minus-Aggressive*, *Robust-Minus-Weak*, and *Momentum*; all taken from Kenneth French's website). In column (3), we additionally control for abnormal returns of different industry indices. In column (4), we add year-times-quarter fixed effects. Column (5) is a placebo test in which we consider neutral sentiment events. The two rows at the bottom of each table indicate the number of considered speeches by sentiment in each regression specification. In all specifications, we cluster standard errors at the date level. T-statistics are reported in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively.

Panel A: Eurozone Commercial Banks

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	Baseline	**Factors**	**Industry Controls**	**Fixed Effects**	**Placebo**
Positive Sentiment	-0.0014	-0.0009	-0.0007	-0.0011	
	(-1.01)	(-0.84)	(-0.70)	(-1.11)	
Neutral Sentiment					0.0016
					(1.33)
Market	1.2035***	0.9633***	0.9508***	0.9483***	0.9478***
	(28.91)	(33.75)	(44.95)	(44.88)	(44.86)
Constant	-0.0000	0.0001	0.0002	-0.0015	-0.0015
	(-0.16)	(0.61)	(1.02)	(-1.04)	(-1.04)
Observations	138,281	138,281	136,887	136,887	136,887
Adjusted R-squared	0.3440	0.4958	0.5263	0.5272	0.5273
Stock Return Factors	No	Yes	Yes	Yes	Yes
Industry Controls	No	No	Yes	Yes	Yes
Year x Quarter FE	No	No	No	Yes	Yes
# Positive Speeches	69	69	69	69	-
# Neutral Speeches	-	-	-	-	58

Panel B: U.S. Commercial Banks

	(1) Baseline	(2) Factors	(3) Industry Controls	(4) Fixed Effects	(5) Placebo
Positive Sentiment	-0.0007	0.0010	0.0002	0.0002	
	(-0.50)	(1.18)	(0.26)	(0.23)	
Neutral Sentiment					-0.0005
					(-0.73)
Market	1.1390***	1.0686***	1.1094***	1.1103***	1.1104***
	(32.79)	(60.94)	(76.29)	(75.16)	(75.28)
Constant	-0.0000	0.0001	-0.0000	-0.0013*	-0.0013*
	(-0.15)	(0.38)	(-0.02)	(-1.91)	(-1.91)
Observations	684,321	684,321	684,321	684,321	684,321
Adjusted R-squared	0.4498	0.6952	0.7143	0.7149	0.7149
Stock Return Factors	No	Yes	Yes	Yes	Yes
Industry Controls	No	No	Yes	Yes	Yes
Year x Quarter FE	No	No	No	Yes	Yes
# Positive Speeches	69	69	69	69	-
# Neutral Speeches	-	-	-	-	58

Table 5: Digital Euro Event Studies – Heterogeneity Across U.S. Payment Firms

This table reports the results from event study panel regressions of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The sample period is from 2016 to 2022. The dependent variables are daily stock returns of U.S. payment firms. Observations are weighted by firms' previous day's market capitalization. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. *Positive Sentiment* is a dummy variable that takes a value of one if there is an event with a positive sentiment towards the digital euro on a given day and otherwise takes a value of zero. *Market* is the daily return of the market in excess of the risk-free rate. In column (1) we only consider *International* payment firms, which we define as payment firms that had positive non-U.S. sales in 2015. In column (2) we only consider *Domestic* payment firms, which we define as payment firms that did not have any non-U.S. sales in 2015. In column (3) we only consider *Pure-Play* payment firms, which we define as payment firms with a 'Net Interest Income/Net Revenues'-ratio of at most 1% as of 2015. In column (4) we only consider *Diversified* payment firms, which we define as payment firms with a 'Net Interest Income/Net Revenues'-ratio larger than 1% as of 2015. In all specifications, we control for common stock return factors, abnormal returns of different industry indices, and year-times-quarter fixed effects. The second to last row indicates the number of considered events in each regression specification. The last row indicates the average aggregate market capitalization of all considered firms throughout the sample period. In all specifications, we cluster standard errors at the date level. T-statistics are reported in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively.

	(1)	**(2)**	**(3)**	**(4)**
	Geography		**Business Model**	
	International	**Domestic**	**Pure-Play**	**Diversified**
Positive Sentiment	-0.0021**	0.0005	-0.0020**	-0.0011
	(-2.04)	(0.47)	(-1.97)	(-0.77)
Market	1.1660***	1.1186***	1.1507***	1.1966***
	(42.06)	(37.27)	(42.53)	(27.20)
Constant	-0.0002	-0.0002	0.0003	-0.0018
	(-0.16)	(-0.12)	(0.32)	(-0.67)
Observations	29,594	14,387	57,769	4,280
Adjusted R-squared	0.5404	0.4503	0.5219	0.6375
Stock Return Factors	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes
Year x Quarter FE	Yes	Yes	Yes	Yes
# Positive Speeches	69	69	69	69
Market Cap (USDm)	854,208	39,686	860,006	119,589

Table 6: Digital Euro Event Studies – Heterogeneity Across Eurozone Payment Firms

This table reports the results from firm-level event study regressions of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The sample period is from 2016 to 2022. The dependent variables are daily stock returns of individual payment firms from the Eurozone. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. *Positive Sentiment* is a dummy variable that takes a value of one if there is an event with a positive sentiment towards the digital euro on a given day and otherwise takes a value of zero. *Market* is the daily return of the market in excess of the risk-free rate. We control for common stock return factors, abnormal returns of different industry indices, and year-times-quarter fixed effects. The last row indicates the average market capitalization of each firm throughout the sample period. In all specifications, we cluster standard errors at the date level. T-statistics are reported in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
	Adyen	**Nexi**	**Worldline**	**Edenred**	**Wirecard**	**Ingenico**	**Ease2pay**
Positive Sentiment	0.0063**	0.0013	0.0034	0.0027*	-0.0048	-0.0042	-0.0059*
	(2.41)	(0.58)	(1.62)	(1.65)	(-0.46)	(-0.62)	(-1.74)
Market	1.0372***	0.9501***	0.8447***	0.7277***	0.8748***	0.8619***	0.7253***
	(13.55)	(9.79)	(15.47)	(16.22)	(5.55)	(11.16)	(5.43)
Constant	0.0108	0.0011	-0.0001	0.0002	-0.0047	-0.0022	-0.0020
	(0.94)	(0.48)	(-0.05)	(0.06)	(-0.97)	(-0.75)	(-0.40)
Observations	1,156	934	1,776	1,776	1,758	1,228	1,760
Adjusted R-squared	0.4873	0.4163	0.3785	0.3830	0.0225	0.3108	0.0213
Stock Return Factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market Cap (USDm)	45,279	12,016	11,293	9,757	8,478	6,288	20

Table 7: Digital Euro Event Studies – Heterogeneity Across Speeches

This table reports the results from event study panel regressions of the form outlined in Equation (1). We rely on the BIS database from Auer, Cornelli, and Frost (2020) and define events as days on which there is communication on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The sample period is from 2016 to 2022. In Panel A, the dependent variables are daily stock returns of Eurozone payment firms. In Panel B, the dependent variables are daily stock returns of U.S. payment firms. Observations are weighted by firms' previous day's market capitalization. We define payment firms as listed firms that simultaneously i) have a SIC code of '6099' or '6141' or a SIC code that does not start with '6', and ii) whose *Compustat* business description contains the words 'payment' or 'merchant solution'. *Positive Sentiment* is a dummy variable that takes a value of one if there is an event with a positive sentiment towards the digital euro on a given day and otherwise takes a value of zero. *Market* is the daily return of the market in excess of the risk-free rate. Column (1) is our benchmark and corresponds to column (4) from Table 3 (*"Fixed Effects"*). In Columns (2) to (5), we gradually exclude specific observations from the set of considered speeches based on a detailed manual review of the speech transcripts. In column (2), we exclude speeches with a generic title. In column (3), we exclude speeches that are rather generic in their content and treat topics related to the digital euro only as a minor subject. In column (4), we exclude speeches that do not provide any new information on the future introduction of the digital euro. In column (5), we exclude all speeches that we do not classify as 'top speeches' (i.e., those that do not provide very material new information). We control for common stock return factors, abnormal returns of different industry indices, and year-times-quarter fixed effects. The last row indicates the number of considered speeches in each regression specification. In all specifications, we cluster standard errors at the date level. T-statistics are reported in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively.

Panel A: Eurozone Payment Firms

	(1) BIS Classification	**(2) Excl. Generic Title**	**(3) Excl. Generic Content**	**(4) Excl. No News**	**(5) Only Top Speeches**
Positive Sentiment	0.0052***	0.0055***	0.0056***	0.0070***	0.0121**
	(2.99)	(2.97)	(2.89)	(2.75)	(2.26)
Market	0.9661***	0.9676***	0.9659***	0.9655***	0.9631***
	(28.23)	(28.25)	(28.21)	(28.15)	(28.00)
Constant	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
	(-0.14)	(-0.13)	(-0.13)	(-0.13)	(-0.13)
Observations	10,895	10,895	10,895	10,895	10,895
Adjusted R-squared	0.3320	0.3321	0.3320	0.3320	0.3321
Stock Return Factors	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes
Year x Quarter FE	Yes	Yes	Yes	Yes	Yes
# Positive Speeches	69	61	57	34	12

Panel B: U.S. Payment Firms

	(1) BIS Classification	(2) Excl. Generic Title	(3) Excl. Generic Content	(4) Excl. No News	(5) Only Top Speeches
Positive Sentiment	-0.0019**	-0.0020**	-0.0021**	-0.0027**	-0.0039***
	(-2.03)	(-1.99)	(-1.97)	(-2.09)	(-3.25)
Market	1.1560***	1.1556***	1.1556***	1.1551***	1.1550***
	(43.21)	(43.17)	(43.17)	(43.11)	(43.16)
Constant	-0.0001	-0.0001	-0.0001	-0.0000	-0.0001
	(-0.06)	(-0.06)	(-0.06)	(-0.05)	(-0.06)
Observations	62,049	62,049	62,049	62,049	62,049
Adjusted R-squared	0.5160	0.5160	0.5160	0.5160	0.5160
Stock Return Factors	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes
Year x Quarter FE	Yes	Yes	Yes	Yes	Yes
# Positive Speeches	69	61	57	34	12

Appendix

Appendix A.1: Members of the Digital Euro Market Advisory Group

Name	Position	Firm	Category	Location
Aleksander Kurtevski	Managing Director	Bankart	Payment firm	Europe
Alessandro De Cristofaro	Director Digital Innovation Strategy	CRIF	Credit scoring	Europe
Antonio Macias Vecino	Head of Payments Discipline	BBVA	Bank	Europe
Axel Schaefer	Payment Regulation and Innovation Specialist	Ingka Group (IKEA)	Retail trade	Europe
Cristian Cengher	Product Owner Cross Border Payments	Erste Group Bank AG	Bank	Europe
Cyril Vignet	Project Manager Innovation	Banque Populaire Caisse d'Epargne	Bank	Europe
Diederik Bruggink	Head of Payments and Innovation	European Savings and Retail Banking Group	Banking association	Europe
Etienne Goosse	Director General	European Payments Council	Banking association	Europe
Fanny Solano	Director Digital and Retail Regulation, Transparency and Implementation	CaixaBank	Bank	Europe
Fernando Rodriguez Ferrer	Head of Business Development	Bizum	Payment firm	Europe
Gerard Hartsink	Chairman	ICC DSI Industry Advisory Board	Industry association	Europe
Inga Mullins	CEO	Fluency	Payment firm	Europe
Jens Holeczek	Head of Digital Payment Unit	National Association of German Cooperative Banks	Banking association	Europe
Jochen Siegert	Managing Director, Global Head of Asset Platforms	Deutsche Bank AG	Bank	Europe
Nicolas Kozakiewicz	Chief Innovation Officer	Worldline	Payment firm	Europe
Nilixa Devlukia	CEO	Payments Solved	Payment firm	Europe
Nils Beier	Managing Director	Accenture Strategy & Consulting	Consulting firm	Europe
Paul Le Manh	Advisor to CEO	EPI Interim Company	Payment firm	Europe
Piet Mallekoote	Former CEO	Dutch Payments Association	Payment association	Europe
Regis Folbaum	Head of Payments	La Banque Postale	Bank	Europe
Roberto Catanzaro	Chief Strategy and Transformation Officer	Nexi Group	Payment firm	Europe
Ruth McCarthy	Managing Director	FEXCO Corporate Payments	Payment firm	Europe
Sean Mullaney	Head of Payment Engineering, EMEA Payments	Stripe	Payment firm	U.S.
Silvia Attanasio	Head of Innovation	Associazione Bancaria Italiana	Banking association	Europe
Sofia Lindh Possne	Senior Advisor, Group Regulatory Affairs	Swedbank	Bank	Europe
Stefano Favale	Head of Global Transaction Banking	Intesa Sanpaolo	Bank	Europe
Teresa Mesquita	Chief Marketing and Product Officer	SIBS Forward Payment Solutions	Payment firm	Europe
Valdis Bergs	Chairman of the Board	Mobilly sia	Payment firm	Europe
Ville Sointu	Head of Emerging Technologies	Nordea	Bank	Europe
Yves Blavet	Open Banking Director	Societe Generale	Bank	Europe

Appendix B: Textual Analysis of Central Bank Communication vis ChatGPT

The below text outlines the instructions provided to ChatGPT for classifying transcripts of central bank speeches on the digital euro. To obtain speech transcripts, we rely on the BIS database from Auer, Cornelli, and Frost (2020) and consider speeches on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. When analyzing speech transcripts, we set ChatGPT's creativity parameter ("temperature") to zero. The topics of interest included in the analysis are: 'Strategic Autonomy', 'Financial Inclusion', 'Privacy', 'Cost Efficiency', 'Monetary Policy', and 'Financial Stability'. The model employed is gpt-3.5-turbo-0613. To accommodate the model's character limit, we segment longer speech transcripts into text snippets of up to 4,000 characters and aggregate ChatGPT's feedback on individual text snippets to the transcript level.

System Instruction:

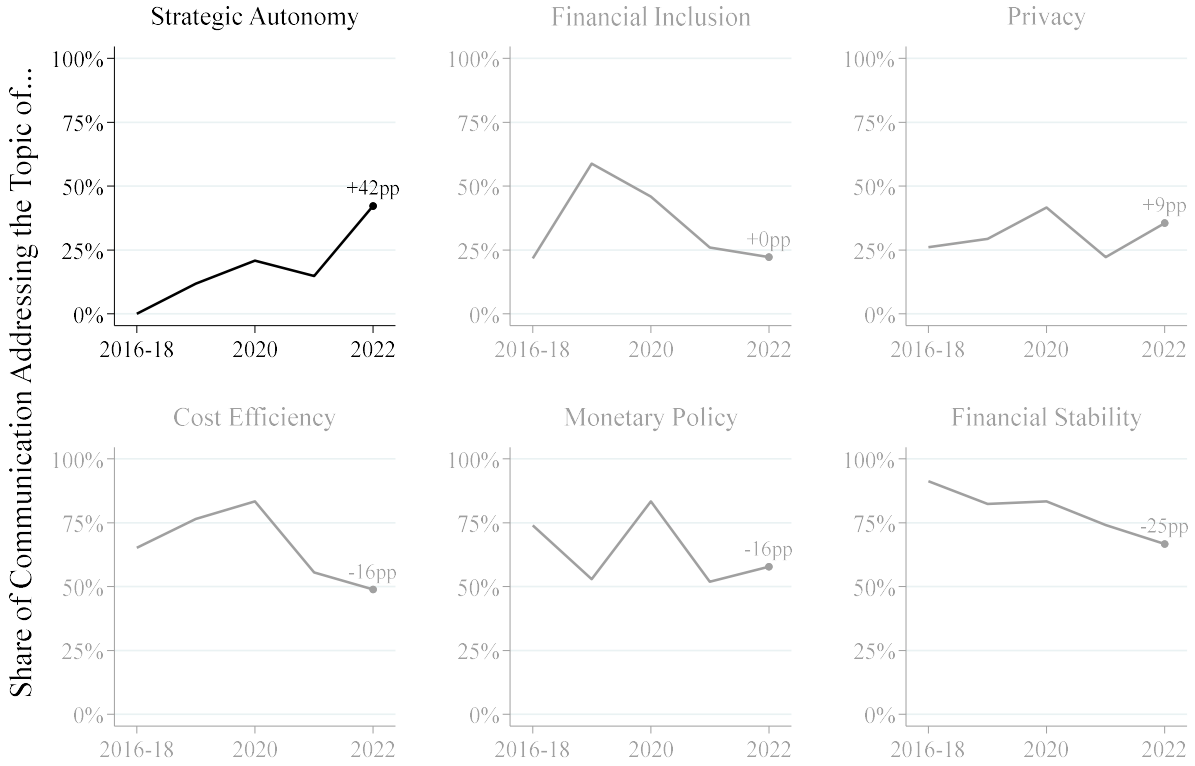
"You are a highly competent and helpful academic research assistant. You have superb reasoning and language processing skills and an IQ of 125. You are an expert in analyzing and understanding central bank communication."

User Prompt:

"I will provide a text snippet from the transcript of a speech on central bank digital currencies (CBDCs). Your task is to analyze the content of the text snippet. Specifically, you should determine whether the text snippet addresses the following topics (delimited by semicolon): [LIST OF TOPICS]
For each topic, your answer should be 'yes' if the text snippet addresses the respective topic, and 'no' in all other cases. Your answer should be structured as follows: '[topic1]: [yes/no]; [topic2]: [yes/no]; (...); [topic_n]: [yes/no]'. For each topic, your answer should only consist of the [topic] itself and 'yes' or 'no'. You are not allowed to use any other words in your answer. Do not apologize if you cannot analyze a specific text snippet for a specific topic, but just answer with '[topic]: no' in this case. Here is the text snippet from the speech transcript: [TEXT SNIPPET]"

Appendix B.1: Topics Discussed in Central Bank Speeches on the Digital Euro

This figure illustrates the annual frequency with which central bank speeches on the digital euro discusses six key topics. We rely on the BIS database from Auer, Cornelli, and Frost (2020) and consider speeches on the digital euro from representatives of either the ECB or individual member countries of the Eurozone. The sample period is from 2016 to 2022. Due to the comparably low number of speeches between 2016 and 2018, we consider those years together. The plotted lines refer to the number of central bank speeches that address a given topic relative to the total number of central bank speeches on the digital euro in a given year. Numbers at the end of each line refer to the percentage points difference between the frequency in 2022 and the frequency in 2016-2018. To determine whether a given speech addresses a specific topic, we analyze central bank speech transcripts via ChatGPT (details outlined under Appendix B).



Internet Appendix

Internet Appendix A: Payment Value Chain

Internet Appendix Table A.1 below provides an overview of the parties involved in a retail payment process with credit or debit cards. Three key payment services are needed for a merchant to accept payments:

(1) *Payee-facing (Acquirer/Processor/Facilitator)* – The acquirer/processor/facilitator (i) provides a bank account where the payment is deposited, (ii) provides a POS-terminal (in-store) or a payment gateway (e-commerce) where cardholders swipe their cards or enter card details, (iii) processes the payment to the card networks. Note that the acquirer can provide these services as a bundle; however, there are also many specialist companies that focus only on parts of the value chain.

(2) *Network* – The card networks (Visa, Mastercard, American Express, Discover) set the rules and standards and process the payment from the acquirer to the card issuer, including authorization (for example, checking anti-money laundering and sanctions regulation), clearing and settlement (settlement between banks).

(3) *Payer-facing (Issuing bank)* – The issuing bank maintains the bank relationship with the cardholder and is involved in authorization (for example, checking for sufficient funds in the cardholders' bank account) and settlement (settlement within the bank, that is, deducting the amount from the cardholders' bank account).

Two types of business models warrant more information. First, payment facilitators like PayPal, Stripe, and Block (formerly named Square) underwrite firms to accept (online) payments, they are thus part of the payee-facing part of the payment value chain. They essentially speed up the merchant onboarding process from weeks or days to just a few minutes. Formally, they sign up merchants as sub-merchants under their own merchant license and, therefore, also bear the processing and fraud risk for their sub-merchants. Payment facilitators frequently offer additional services (such as PayPal's seller protection or Block's card reader). Second, Apple Pay and Google Pay have carved out part of the issuing banks' value chain. For their services, they receive part of the interchange fees. Note also that interchange fees, i.e., fees earned in the payer-facing part of the value chain, are heavily regulated across the world, while card scheme fees and acquirer markups are not. Third, the business model of American Express and Discover differs from that of Visa and Mastercard in that they also issue credit cards themselves.

Merchants typically bear credit and fraud risk of the cardholder if they decide to accept payments without strong authentication (credit card number only, or credit card plus signature), while the issuing bank typically bears credit and fraud risk for payments with strong authentication (for example, where a PIN number is entered). The acquirer/processor/facilitator bears merchant credit risk and merchant fraud risk. If for example, the merchant sells a service (such as a flight) but does not provide the service, the cardholder can require a chargeback. Chargebacks are first borne by the merchant, however, if the merchant is not willing or not able to pay – which can be due to merchant credit risk or outright fraud on the merchant side – the acquirer must refund the cardholder.

Internet Appendix A.1: Payment Value Chain

	Payee: Merchant	Payee-facing: Acquirer/Processor, Facilitator	Networks	Payer-facing: Issuing Bank	Payer: Cardholder
Key Function	· Sells goods and services	· POS-terminal (in-store) / payment gateway (e-commerce) · Acquirer processing[34] · Merchant bank account · Facilitator: underwrites firms to accept (online) payments	· Set rules and standards · Network processing	· Issuer processing[1] · Cardholder bank account	· Buys goods and services
Credit and Fraud Risk	· Credit and fraud risk for transactions not verified via the issuing bank (e.g., card number only)	· Merchant credit risk[35]	· None	· Credit and fraud risk for transactions verified via the issuing bank (e.g., PIN, or 3D-secure)	· None (exception: gross negligence)
Fees	· Product price minus acquirer markup, scheme fees, and interchange fee	· Acquirer markup	· Scheme fees	· Interchange fee	· Product price
Fee Amount	· 50-350bps depending on payment method and location	Worldwide Ø: · *FIS:* 13bps · *Adyen:* 22bps · *PayPal:* 146bps[36] · *Square/Block:* 125bps	Worldwide Ø: · *Visa:* 19bps · *Mastercard:* 23bps · *American Express* and *Discover* not comparable[37]	U.S, and Europe Ø:[38] · U.S. Debit: 73bps · U.S. Credit: 174bps · Europe Debit: 20bps · Europe Credit: 30bps	· Not applicable
Examples	· *Walmart, Target, Wayfair, Etsy*	· POS-terminal: *Ingenico, Verifone* · Gateway and acquirer processing: *FIS, Chase Paymentech, Global Payments, Adyen* · Facilitator: *PayPal, Square/Block*	· *Visa, Mastercard*	· *Bank of America, Citigroup, Wells Fargo* · Other parts of the value chain: *Apple Pay*, *Google Pay*[39]	· Jane Doe, John Doe

[34] *Acquirer processing*: Merchant to Network and Network to Merchant. *Network processing*: authorization (e.g., AML and sanction laws), clearing, and settlement. *Issuing bank processing***:** authorization (e.g., availability of funds), settlement.
[35] Mainly chargeback-induced credit risk. Chargeback can occur for many reasons; a prominent one is consumer disputes. If a service was paid for but not received (e.g., because an airline goes bankrupt), then consumers can require a chargeback. If the merchant is unable to pay the chargeback, the acquirer needs to pay.
[36] Excluding pass-through (scheme fees, interchange fees). PayPal offers payment via a PayPal account that links email addresses to credit card and account numbers. Both PayPal and Square/Block provide further services to merchants (such as PayPal seller protection or Square reader).
[37] American Express and Discover act as acquirers, networks, and issuers. American Express, for example, earned USD 36.1 billion in revenue in 2020, equivalent to 361bps of their payment volume of 1.0 trillion.
[38] In the U.S., debit card interchange fees are limited by the Durbin Amendment, applicable to banks with over USD 10 billion in assets, to 21 cents plus 5bps of the transaction (plus 1bp for fraud-prevention measures). In Europe, consumer debit card fees are capped at 20bps, consumer credit card fees at 30bps.
[39] Services like Apple Pay and Google Pay sit between the issuing bank and the cardholder. These services promise to offer better customer satisfaction as well as lower fraud rates. The issuing bank typically passes part of the interchange fee to these service providers (initially 15bps in the U.S. for credit card transactions).

Internet Appendix B.1: Manual Classification of Central Bank Speeches with a Positive Stance on the Digital Euro

This tables includes information on all Eurosystem speeches Auer, Cornelli, and Frost (2020) classify as positive towards CBDC (using the July 2023 update). For the original data source see https://www.bis.org/publ/work880.htm. The table includes the date (which we checked and corrected in some cases) and the title of the speech (with a hyperlink to the transcript on the BIS webpage). We manually went through every speech and added variables in columns. *Generic Title* takes values of either 'Yes' or 'No' to indicate if the title of the speech is generic[40]. *Generic Content* is 'Yes' if the content of the speech is to a large extend general, generic, and/or about unrelated topics (otherwise it is 'No'). Column *News* is 'Yes' when the speech does not contain any substantial and positive news on a retail CBDC. Column *Top* we classify as 'Yes' when a speech is outstanding. This can happen when a speaker communicates especially important new positive information on retail CBDC (for example, about concrete actions in the near future). *New Information* contains bullet points summarizing key information from the speech. Negative news, news on wholesale CBDC, or minor news on retail CBDC may be listed in *New Information* while *News* is coded as 'No'. For the columns *News*, *Top*, and *New Information* we used the sample of positive Eurosystem speeches in the BIS database. Some information relevant for classifications in these columns may be in speeches the BIS does not classify as "positive"; in some speeches the BIS may fail to report; or in other Eurosystem communication.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
1	30-Dec-17	Benoît Cœuré: Interview in Caixin Global	Yes	Yes	No	No	ECB in early stages of discussion on wholesale CBDC (like most other central banks); critical of DLT applications for CBRD (unsuccessful past project); ECB is "much more prudent" on retail CBDC.
2	12-Apr-19	Vitas Vasiliauskas: Central bank digital currencies	No	No	No	No	For now, CBDCs seem like a quite distant prospect.
3	17-Oct-19	Benoît Cœuré: Interview with Bloomberg	No	No	Yes	No	Do not want payments to be dominated by US and Chinese actors; "I'm personally pretty sure CBDCs will come. I don't know how and in which form. It may come in different ways in different jurisdictions."
4	4-Dec-19	François Villeroy de Galhau: Central bank digital currency and innovative payments	No	No	Yes	Yes	Wants to start running CBDC experiments with the private sector rapidly; financial intermediaries to play key role in CBDC distribution; want to develop a genuine pan-European payment solution; BDF to be restructured accordingly.

[40] In case of interviews – which always have generic titles – we check whether interview questions are generic in nature or focused on CBDCs.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
5	8-Jan-20	Christine Lagarde: Interview in "Challenges" magazine	Yes	Yes	No	No	ECB expert task force created to study CBDC creation.
6	15-Jan-20	Denis Beau: Stablecoins – a good or a bad solution to improve our payment systems?	No	No	No	No	Retail CBDC could help for cross border payments.
7	11-Feb-20	Christine Lagarde: Debate about the Annual Report	Yes	Yes	No	No	Eurosystem task force on CBDC to investigate how CBDC would work in practice, joint discussion with five central banks and BIS.
8	3-Mar-20	Denis Beau: What financial sovereignty in a digital world?	No	No	Yes	Yes	ECB sees risk of dependance on foreign dominant players VISA and Mastercard. Europe's sovereignty over payments will be more secure if it can rely on its (own) private and industrial players. Need for collective interest projects to ensure independence, for example, ECB supports the European Payment Initiative (EPI) as a milestone in the creation of an integrated European payment area.
9	11-May-20	Yves Mersch: An ECB digital currency – a flight of fancy?	No	No	Yes	No	Focus on retail CBDC and cooperation with lawmakers for legal basis; disintermediation of banks would be untenable.
10	10-Sep-20	Christine Lagarde: Payments in a digital world	No	No	Yes	Yes	ECB to announce public consultation process after task force results released in the coming weeks; Eurosystem has set out European payment strategy to actively advance European initiatives to strengthen European payments; CBDC can be a safeguard for monetary authority.
11	10-Sep-20	Jens Weidmann: Welcome address for Christine Lagarde	Yes	Yes	No	No	-
12	11-Sep-20	François Villeroy de Galhau: Preparing Europe Payments for the digital currency age	No	No	Yes	Yes	BigTechs and other CBDCs are significant risks; "we do not have much time": CBDC and European payment strategy need to be decided in 1-2 years; quantity limits can prevent excessive shifts of commercial bank money.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
13	7-Oct-20	François Villeroy de Galhau: Brexit, digital payments, seize the day	No	No	Yes	Yes	ECB experiments with European CBs on retail CBDCs; decide until mid-2021 on starting investigation phase/project launch; support of European private payment infrastructure and European CBDC are no contradiction because of planned public private partnership and dissemination.
14	12-Oct-20	François Villeroy de Galhau: The digital payment revolution	No	No	No	No	-
15	15-Oct-20	Denis Beau: For a contribution from our FinTech ecosystem to a more efficient and stable financial system	No	Yes	No	No	-
16	27-Nov-20	Jens Weidmann: Shaping the future – challenges in the European payments market	No	No	Yes	No	CBDC public alternative to foreign payment initiatives; two tier renumeration scheme to curb financial stability risks possible; CBDC bound to take time.
17	27-Nov-20	Fabio Panetta: From the payments revolution to the reinvention of money	No	No	Yes	Yes	Digital Euro will be means of payment, not store of value; Digital Euro will be ecosystem (facilitates value added services, e-invoice, e-identity); speech further provides technical details on ECB experiments.
18	7-Dec-20	Alessandra Perrazzelli: Digitalisation and financial services innovation in the Italian G20 Presidency Agenda	No	No	No	No	Italian G20 presidency will focus on new technologies including new efficient payment system.
19	8-Dec-20	François Villeroy de Galhau: The Pig, the frog and the elephant - towards a better regulation of digital innovation	No	No	Yes	No	Cannot allow ourselves to lack behind on CBDC; Banque de France (BDF) and Monetary Authority of Singapore (MAS) to conduct joint tests on wholesale CBDC.
20	10-Dec-20	Denis Beau: Innovations in the financial sector and central banks' contributions	No	No	Yes	No	Eurosystem has adopted a similarly hands-on/positive approach as Banque de France (positive news because BDF lead on CBDC); successful and promising experiment with Société Générale (interfacing public and private blockchains)
21	10-Feb-21	Fabio Panetta: Evolution or revolution? The impact of a digital euro on the financial system	No	No	Yes	Yes	CBDC an answer to many problems: competition, dependence on technologies governed elsewhere, unifying the European market. Digital Euro to be available to households, firms, merchants, and financial intermediaries. Would increase consumer choice and reduce transaction costs. First mentioning of 3000 Euro holding limit to prevent investment/excessive flows.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
22	8-Apr-21	Denis Beau: Navigating the digital transition, maintaining a stable payment system	No	No	Yes	No	Singles out European Payment Initiative (EPI) and states Digital Euro should interoperate smoothly with EPI; update on timeline.
23	10-Jun-21	Burkhard Balz: Digital payments & European sovereignty	No	No	Yes	No	Dissects role of international players in each level of payment system; forceful on strategic autonomy / Digital Euro as a solution.
24	28-Jun-21	Ignazio Visco: Back to the future of money	No	No	No	No	G20 presidency of Italy considers cross border use of CBDC as key topic.
25	29-Jun-21	François Villeroy de Galhau: Roads for the future - central bank digital currency (CBDC) and innovative payments	No	No	Yes	Yes	Reveals decision in 2023 about Digital Euro launch “within a few years”; welcomes EPI to participate in prototyping CBDC; reveals host of technical details on Digital Euro experiments.
26	12-Jul-21	Denis Beau: New technologies and monetary policy frameworks	No	No	Yes	No	Update on Digital Euro experiments; details on possible design to make Digital Euro attractive for everyday payments/unattractive as store of value.
27	12-Jul-21	Piero Cipollone: TIPS (TARGET Instant Payment Settlement) - the new Eurosystem market infrastructure service - Banca d'Italia as service provider and manager of the business relationships with the financial community	No	No	Yes	No	TIPS potential technical solution for Digital Euro (which is a system in place and already now allows for up to 1bn transactions per day).
28	29-Jul-21	Gabriel Makhlouf: Digital money	No	No	Yes	No	Digital Euro very likely to happen, ‘not a question of "if" but rather "how and when"’; CBs decided on prototype/investigation phase.
29	30-Sep-21	Denis Beau: The digitalisation of the financial sector - new challenges, new levers	No	No	No	No	-
30	11-Oct-21	François Villeroy de Galhau: Bank of France - how the commitment to fintechs is being implemented	No	No	Yes	No	Details on cooperation/experiments with (French) FinTech on CBDC; decision in 2023 about a launch in 2026.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
31	3-Nov-21	Burkhard Balz: Shaping Europe together	No	No	Yes	No	Important that ECB delivers backend infrastructure, but up to (European) private sector to develop end user solutions.
32	8-Nov-21	François Villeroy de Galhau: Digital innovation - what role can we play as central banks?	No	No	No	No	Details on international cooperation; report on key takeaways from experiments published today.
33	19-Nov-21	Denis Beau: The challenges of the digital euro	No	No	Yes	No	Commercial banks to be involved in Digital Euro design to avoid undesirable consequence.
34	25-Nov-21	François Villeroy de Galhau: Central banks and finance in the face of a triple revolution	No	No	Yes	Yes	CBDC as the only alternative to unchecked development of DeFi. Holding of retail Digital Euro will be capped if/when introduced, Digital Euro will have a neutral renumeration rate, expects "go" decision for European Payment Initiative (EPI) in next days.
35	4-Jan-22	François Villeroy de Galhau: New Year wishes to the Paris financial centre	Yes	Yes	No	No	-
36	19-Jan-22	François Villeroy de Galhau: Rising temperatures - inflation, climate change and digital transformation	No	No	Yes	No	Reiterates need for regulation of DeFi and innovation of CBDC; first use of "strategic autonomy" in positive sentiment speech.
37	4-Feb-22	François Villeroy de Galhau: Twenty years later- and twenty years ahead	No	No	Yes	No	"EU should at once … prepare for a CBDC … by 2026".
38	14-Feb-22	Christine Lagarde: 20th anniversary of the entry into circulation of euro banknotes and coins	No	No	No	No	-
39	24-Mar-22	Denis Beau: From open banking to open finance	No	No	Yes	No	Expert advisory group set up to advise on design of Digital Euro; must use industrial lever and encourage innovation by European players.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
40	8-Apr-22	Fabio Panetta: More than an intellectual game - exploring the monetary policy and financial stability implications of central bank digital currencies	No	No	Yes	No	Enabling large payments while having holding limits can be made possible by linking CBDC to private money accounts (later dubbed 'waterfall mechanism'); some more details on two-tiered renumeration.
41	15-Apr-22	Denis Beau: What role should banks play in the twin digital and climate revolution?	No	No	No	No	Timeline update: final decision on launch of a Digital Euro in Q4 2023 (2023 communicated before).
42	25-Apr-22	Fabio Panetta: For a few cryptos more - the wild west of crypto finance	No	Yes	No	No	-
43	16-May-22	Fabio Panetta: Public money for the digital era - towards a digital euro	No	No	Yes	Yes	Digital Euro a protection against weaponization of dependencies and technology, first mentioning of geopolitics; could give Digital Euro legal tender status which would require every merchant to accept it; Digital Euro could have more privacy than other payments; similarity to PIX scheme; about to engage with European Commission, Parliament, and finance ministers "at every stage of the project" (investigation phase) to define a legal framework.
44	16-May-22	François Villeroy de Galhau: Multipolarity and the role of the euro in the International Financial System	No	Yes	No	No	-
45	22-Mar-22	François Villeroy de Galhau: Central banks in a distributed-ledger technologies world	No	No	No	No	-
46	31-May-22	Ignazio Visco: Overview of economic and financial developments in Italy	Yes	Yes	No	No	-
47	15-Jun-22	Fabio Panetta: The digital euro and the evolution of the financial system	No	No	Yes	Yes	Complete Digital Euro rationale and architecture presented to European Parliament: i) strategic autonomy and geopolitical considerations key motivation, requiring European payment solution, ii) call for parliament for legislation as legal tender, iii) private public partnerships for distribution; iv) specific design choices to limit downsides for banks.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
48	20-Jun-22	Claudia Buch: 30 years of monetary reform in Estonia - lessons learned for the decade ahead	Yes	Yes	No	No	Estonian CB involved in Digital Euro
49	29-Jun-22	Burkhard Balz: The landscape in 2030 - Central Bank Digital Currencies (CBDC) or private digital payment solutions?	No	No	Yes	Yes	Expects CBDC will receive legal tender status and be accepted nearly everywhere; could use offline capability, differentiating it from other digital payment forms; Digital Euro not just a digital version of cash, but an entire payment scheme similar to card schemes (rulebook governing the use; add-on services could be built on top by payment service providers).
50	12-Jul-22	François Villeroy de Galhau: Central bank digital currency (CBDC) and bank intermediation in the digital age	No	No	No	No	EPI as a potential vehicle to distribute CBDC; decision on launch slightly postponed in late 2023/early 2024; update on experiments on wholesale CBDC.
51	11-Jul-22	Joachim Nagel: Digital euro - opportunities and risks	No	No	Yes	No	Details on possible CBDC offline use (exemptions from money laundry checks); differences in tiered remuneration system between retail and merchant customers.
52	23-Aug-22	Olli Rehn: Beyond crypto-mania - digital euro as monetary anchor	No	No	No	No	Decision on launch in October 2023; CBDC as potential solution to cyberattacks.
53	30-Aug-22	Margarita Delgado: Central bank money for the digital age - reflections on the new paradigm	No	No	No	No	Discussion of reputation risk for ECB given the increase of responsibilities.
54	7-Sep-22	Burkhard Balz: The digital euro – an opportunity for Europe	No	No	No	No	Apple singled out for restrictive competitive action, discussion of Alipay and eYuan.
55	14-Sep-22	François Villeroy de Galhau: Ethics of currency - a possible guide for central bankers?	No	Yes	No	No	-
56	26-Sep-22	Fabio Panetta: Demystifying wholesale central bank digital currency	No	No	No	No	Two options for wholesale CBDC discussed.

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
57	27-Sep-22	François Villeroy de Galhau: Anchors and catalysts - central banks' dual role in innovation	No	No	No	No	Potential launch of Digital Euro in 2026/27; update on experiments with wholesale CBDC.
58	27-Sep-22	Denis Beau: Opportunities and challenges of the tokenisation of finance - which role for central banks?	No	No	No	No	-
59	26-Sep-22	Joachim Nagel: The shape of money – yesterday, today and tomorrow	No	No	Yes	No	Highlights higher level of data protection for Digital Euro transactions than private sector payment firms.
60	29-Sep-22	Fabio Panetta: Building on our strengths - the role of the public and private sectors in the digital euro ecosystem	No	No	Yes	No	ECB will soon start rulebook development; Eurosystem fully in charge of settlement; lays out first set of design choices.
61	14-Oct-22	Burkhard Balz: The European payment industry in challenging times	No	No	Yes	No	If realization is decided, the CBDC will launch in fall 2026; no complete anonymity even for offline use.
62	14-Oct-22	Christine Lagarde: IMFC Statement	Yes	Yes	No	No	-
63	19-Oct-22	François Villeroy de Galhau: ACPR-AMF Forum Fintech	No	No	No	No	Three more experiments on wholesale CBDC.
64	20-Oct-22	Denis Beau: Between mounting risks and financial innovation - the fintech ecosystem at a crossroads	No	No	No	No	Update on wholesale and retail experiments as part of piloting regime.
65	28-Oct-22	Piero Cipollone: The implementation of CBDCs by central banks - challenges, risks and opportunities	No	No	No	No	Minor update on timeline for investigation period and decision on Digital Euro (specifying September 2022; previously mentioning “autumn”); discussion of results from focus group and legislative challenges.
66	31-Oct-22	Yannis Stournaras: Assessing the impact of digital finance on financial and economic integration - risks, opportunities and challenges for central banks	No	No	No	No	-

#	Date	Speech	Generic Title	Generic Content	News	Top	New Information
67	7-Nov-22	Christine Lagarde: Digital euro - a common European project	No	No	No	No	Citizens rank privacy as most important CBDC characteristic. Right balance between the social value of privacy and the public interest in preventing illicit activities is a political choice and is for the legislators to decide.
68	20-Nov-22	Pablo Hernández de Cos: New digital technologies and the financial system - fintech, crypto and CBDCs	No	No	Yes	No	Third party validation decided as transfer mechanism, further exploring P2P offline validation (less certain); prototype completed in Q3 2023; Eurosystem builds back end, private front end for prototype (54 expressed interest in call).
69	7-Dec-22	Fabio Panetta: Crypto dominos - the bursting crypto bubbles and the destiny of digital finance	No	No	No	No	-