BANCA D'ITALIA
EUROSISTEMA

Mercati, infrastrutture, sistemi di pagamento

(Markets, Infrastructures, Payment Systems)

Business models and pricing strategies in the market for ATM withdrawals

by Guerino Ardizzi and Massimiliano Cologgi

Number 23

July 2022

BANCA D'ITALIA
EUROSISTEMA

Mercati, infrastrutture, sistemi di pagamento
(Markets, Infrastructures, Payment Systems)

Approfondimenti
(Research Papers)

Business models and pricing strategies in the market for ATM withdrawals

by Guerino Ardizzi and Massimiliano Cologgi

Number 23 – July 2022

The papers published in the 'Markets, Infrastructures, Payment Systems' series provide information and analysis on aspects regarding the institutional duties of the Bank of Italy in relation to the monitoring of financial markets and payment systems and the development and management of the corresponding infrastructures in order to foster a better understanding of these issues and stimulate discussion among institutions, economic actors and citizens.

The views expressed in the papers are those of the authors and do not necessarily reflect those of the Bank of Italy.

The series is available online at www.bancaditalia.it.

Printed copies can be requested from the Paolo Baffi Library: richieste.pubblicazioni@bancaditalia.it.

ISSN 2724-6418 (online)
ISSN 2724-640X (print)

Banca d'Italia
Via Nazionale, 91 - 00184 Rome - Italy
+39 06 47921

Designed and printing by the Printing and Publishing Division of the Bank of Italy

Business models and pricing strategies in the market for ATM withdrawals

Guerino Ardizzi* and Massimiliano Cologgi*

Abstract

Automated Teller Machines (ATMs) play a crucial role in retail banking as they represent the primary cash access points for customers. However, the ongoing digitalization of retail payments has put pressure on the ATM industry, raising concerns about its sustainability. We describe the main business models adopted in Europe by ATM service providers, with a special focus on their pricing strategies. We then estimate the price elasticity of the demand for cash withdrawals with a partial adjustment model using data on a panel of Italian banks from 2015 to 2020. Our results show that an increase in disloyalty fees would reduce withdrawals from other banks, leaving the overall demand essentially unchanged. This outcome may reflect a potential shift of consumers towards withdrawals from their own bank as well as cheaper alternative distribution channels.

JEL Classification: E41, E42, G21, G23.

Keywords: payment instruments, interchange fees, ATM fees, price elasticity, cash withdrawals.

Sintesi

Gli sportelli automatici (ATM) svolgono un ruolo cruciale nel settore dei pagamenti al dettaglio in quanto rappresentano i principali punti di accesso al contante per i consumatori. Tuttavia, il processo di digitalizzazione dei pagamenti al dettaglio ha messo sotto pressione il settore degli ATM, sollevando preoccupazioni sulla sua sostenibilità economica. In questo lavoro, descriviamo i principali modelli di business adottati dai fornitori di servizi ATM in Europa, con particolare attenzione alle loro strategie di remunerazione del servizio. Stimiamo quindi l'elasticità alle commissioni della domanda di prelievi di contante con un modello econometrico utilizzando dati su un panel di banche italiane nel periodo 2015-2020. I nostri risultati mostrano che un aumento delle commissioni ridurrebbe significativamente la domanda di prelievi in circolarità, lasciando sostanzialmente invariata la domanda complessiva. Questo risultato può riflettere un potenziale spostamento dei consumatori verso i prelievi presso la propria banca, nonché verso canali distributivi alternativi più convenienti.

* Banca d'Italia, Directorate General for Currency Circulation and Retail Payments.

CONTENTS

1. Introduction[1]

The retail payments sector is experiencing a significant growth in the use of home banking and in the diffusion of electronic instruments, driven by technological innovation, changes in the regulatory framework and the entrance of new operators in the market. The breakout of the pandemic from Covid-19 accelerated the usage of card payments at the physical point-of-sale and e-commerce transactions in many euro-area countries (see Ardizzi, Nobili and Rocco, 2020), but the demand for cash remained sustained not only for transactional purposes, but also for precautionary motives (ECB, 2020; Baldo *et al.*, 2021). This is why the Eurosystem cash strategy for 2030[2] has reaffirmed the importance of a wide cash availability and the need to safeguard cash supply infrastructures in a complementary way with the ongoing project of a digital euro.

Against this background, Automated Teller Machines (ATMs) represent an essential infrastructure for guaranteeing the supply and access to cash to consumers and progressively replaced withdrawals from bank tellers. Thanks to the interoperability of interbank ATM networks, consumers have the opportunity to withdraw cash from their current accounts at any time and from the majority of financial institutions in the country. Financial intermediaries, from their side, are instead evaluating the profitability of cash distribution services and the sustainability of ATMs. The net "return" from cash-related activity seems to be negative, thus reducing the incentives to install new ATMs or maintain the old equipment. Commercial banks, for example, continue to downsize their branch networks and strive for optimizing costs regarding their support for ATM networks.

Pricing policies applied to customers' withdrawals represent a crucial component of banks' business models and the recent changes in regulation exerted a significant impact on their definition and design in euro-area countries. The adoption of the second Payment Services Directive (PSD2) and the Interchange

[1] We thank Elisa Bonifacio, Gabriele Coletti, Michele Lanotte, Andrea Nobili and an anonymous reviewer at the Bank of Italy for very helpful comments.

[2] This strategy (https://www.ecb.europa.eu/euro/cash_strategy/html/index.it.html) reaffirms the importance of being able to pay in cash and the role of cash in terms of financial inclusion. The cash strategy aims to ensure its wide availability and acceptance as a payment instrument and as a store of value, and to safeguard supply infrastructures.

Fee Regulation (IFR) for card-based payment transactions allowed a higher level of transparency and harmonization both in a domestic and in a cross-border context and defined acceptable charging practices also fixing caps on interchange fees applied to both debit and credit card transactions. Cash withdrawal services may be provided by the card issuer - inside its own network or also extending to other networks via a contractual relationship with ATM providers - or by independent ATM providers, which do not act on behalf of card issuers. Banks usually charge fees on "not-on-us" transactions, namely when the service extends to the ATMs of other networks and, in theory, both indirect and direct charging are possible. In the first case, the card issuer compensates the ATM provider for the services rendered to make the cash available to the cardholder, and the card issuer in turn charges a fee to the cardholder. In the second case, both the card issuer and the ATM provider decide that each of them can levy a charge to the cardholder.

In the euro area, the common practice is indirect charging but *de facto* this does not allow the full compensation of costs weighing on ATM providers. The estimates for Italy suggest that banks can cover only 15% of the costs associated with the cash handling service through the prevailing schemes of tariffs and fees (Banca d'Italia, 2020). The direct access fee scheme (DAF) would be more sustainable, but it seems to be widespread only in very few countries, namely Spain and Germany. In this regard, a crucial question is how a potential increase in the fees paid by cardholders stemming from the adoption of the DAF scheme could affect the ATM withdrawals market in Italy.

In order to understand how market demand might react to price changes, in this paper, we use bank-level information to estimate the elasticity of the demand for withdrawals to an increase in fees charged by financial intermediaries. Our results suggest that the overall demand is inelastic to price changes while "not-on-us" transactions significantly declined. We also find that cardholders react to an increase in fees by increasing withdrawals from ATMs managed by their bank. Overall, these results point out that the adoption of the DAF scheme could favor banks characterized by a pervasive network on the domestic territory, thus leading to relevant composition effects in the retail payments market.

The remainder of the paper is the following. We describe and compare the traditional business models in the ATM industry in section 2, and analyze the profitability of ATM withdrawal services in

Italy with reference to the Euro area in section 3. We then look into the existing empirical evidence on the price elasticity of cash withdrawals and estimate a model of market demand for ATM withdrawals in Italy using data on a panel of Italian banks (section 4). Section 5 discusses the main policy implications of our results and concludes.

2. Cash withdrawal services and business models

In this section, we describe the main features of the business models adopted by intermediaries to provide cash to end-users. We focus on distributive schemes and networks aiming at minimizing costs and maximizing the floor of end-users.

The ATMs market – An important feature of the market is the choice of distribution policies of cash via ATMs, which allows intermediaries to minimize operational costs and reach the bulk of end-users on the domestic territory. Most ATMs are provided by small domestic banks, the post office, networks of cooperating banks (e.g. cooperative and savings banks) or collective initiatives by larger banks. In this regard, one can distinguish between on-site ATM machines that are located and managed within the bank premises (branches, post offices) and remote or "stand-alone" ATMs that are located and managed outside the bank premises and usually in places with high pedestrian traffic (on the street, airports, gas stations, etc.). Cash withdrawal services are usually provided by the card issuer, but when the service extends to the ATMs of other networks, card issuers usually enter into a contractual relationship with ATMs providers to agree on the business rules governing the execution of the transaction, which also includes the charging aspects.

Alternatively, independent ATM providers may offer cash withdrawal services directly to end users and without acting on behalf of card issuers. This is the case of independent ATM deployers (IADs), namely non-financial legal entities holding a license as a payment service provider and adhering directly or through other intermediaries to international circuits. The location of independent ATMs depends very much on the targeted type of cardholder. ATMs targeting domestic cardholders are usually located at retail premises and highly frequented sites across both rural and urban area, while independent ATMs targeting international cardholders are predominantly located at main transport locations (airports, train stations, etc.) and tourist areas.

In Italy, the share of “stand-alone” or “independent” branches increased from 13% to 16% between 2015 and 2020; at a European level, this share is higher (30% in 2019).

To compete with innovative solutions in digital payments, ATM service providers have increased the interoperability with digital technologies to improve customer experience. For example, many ATMs offer the possibility to access information services or ATM devices in contactless mode using Near Field Communication (NFC) or QR code technology.

Alternative solutions to expand the opportunities for accessing cash services can also rely on the distribution structure of retail trade, with “cash-back” or “cash-in-shop” services that allow consumers to use the cash available at supermarkets, tobacconists, or other interested merchants, to integrate the offer of bank ATMs in the area, with lower handling charges to and from the banking system.

The ATM card scheme – ATM services are based on a set of rules, practices and standards that allow the execution of card-based withdrawal operations, set by the manager (governance authority) of the ATM brand or scheme (i.e. Visa, Mastercard, Bancomat). The governance authority gives the requiring bank or other financial institution the opportunity (license) to issue a card (issuer) or to acquire ATM devices joining the scheme (acquirer). Issuers and acquirers have direct relationships with customers (cardholders) and apply customer fees (i.e. loyalty fees or direct access fees). However, to join the network, ATM operators need to pay certain fees set by the governance authority (or according to multilateral agreement among participants) to the network administrators or ATM card schemes. These fees, also referred to as wholesale fees, cover the following:

1. Membership fees, paid by the banks or other institutions (as new member) upon joining the network.

2. Monthly/annual fees, paid by the banks or other institutions, usually tied to the sales volumes of the card program.

Additionally, banks as issuers of payment cards must pay charges per transaction, known as service fees, which are as such:

3. Switch fees, paid by the cardholder's bank (i.e. the card-issuing bank) to the network for routing transaction information through the network's computer switching system. They are also paid by the card-acquirers to the network.

4. Interchange fees, paid by the cardholder's bank (i.e. the card-issuing bank) to the ATM owner, i.e. the card acquirer. These fees can be regarded as a compensation for the costs of deploying, maintaining the ATMs and providing a service for customers that keep their payment accounts at another institution. Compared to the interchange fee for card payments at the point-of-sale (POS) where the interchange fee is paid by the card acquirer (retailer) to the card issuer, the ATM interchange fee is also referred to as "reverse interchange fee", as the card acquirer receives the interchange fee.

The fees paid by ATM operators (banks or other institutions) to the scheme are also included in the industrial cost of provision of ATM described in section 3.

The charging models – The most common charging practice targets "not-on-us" transactions, namely those where the ATM provider differs from the card issuer. In this case, the card issuer compensates the ATM provider, irrespectively of whether the latter is independent or with a contractual relationship with the card issuer, for the services rendered to make the cash available to the cardholder by paying the so-called "interchange fee". The card issuer, in turn, charges a withdrawal fee to the cardholder – the so-called "disloyalty" or "foreign" or "not-on-us" fee.[3]

In what follows, we name this "indirect charging" as the interchange fee model (IF). The interchange fee are set by debit and credit card companies that manage the main domestic and international circuits such as Mastercard, Visa, American Express and Diners. Increasing competition aiming at adhering at the various circuits led to a lowering of tariffs.

[3] The charging of the cardholder directly by the ATM provider is usually contractually excluded, as a double charging for the same financial service would contradict the very objective of the card issuer, which is to provide its customer the value-added of access to the ATMs of other networks.

The main advantage of the IF model derives from the fact that the cardholder can control the withdrawal costs based on the current account contract with the issuing bank. The bank, regardless of size and geographical characteristics, can offer an interoperable not-on-us withdrawal service with homogeneous tariff conditions. The main disadvantage, however, lies in the fact that the revenues from IF generally do not cover all the operating costs of the acquirer, who should therefore operate at a loss.[4]

Alternatively, a "direct access fee" (DAF) model is possible within the framework of the contractual relationship between the card issuer and the ATM provider acting on its behalf, with the acquirer bank directly applying a commission to the cardholder. The same applies in the case of IADs, where the card issuer does not have a contractual relationship with the ATM provider.

With respect to the pricing of ATM withdrawal services, there are two main models,[5] which can also be combined together (Appendix, n. 1):

- the interchange fee model (IF) or multilateral interchange fee (more widespread in international circuits), where the card issuer pays a fee in favor of the intermediary that manages the ATM, and then eventually applies a withdrawal fee to its own customer (so-called "disloyalty" or "foreign" or "not-on-us" fee);
- the direct access fee model (DAF) where the acquirer bank directly applies a commission to the holder of the withdrawal card, regardless of the type of contract with the issuer.

For "on-us" transactions, in both the IF and the DAF models the customer does not normally pay a withdrawal commission.

[4] "On-us" withdrawals, on the other hand, although not explicitly charged, are attributable to current account services and deposits, which generate other forms of revenue for the bank.

[5] The models illustrated here consider the main fees that are passed on to customers and do not fully illustrate the complexity of interbank and infrastructural charges that are borne by ATM service providers. In particular, there are also fees for access to the electronic network and for the processing of transactions, in addition to the so-called "scheme fee" and "membership fee" to be paid to the governance authorities of the international card schemes.

For "not-on-us" operations, in Europe only Germany and Spain apply the DAF, in combination also with the IF (i.e. a surcharge fee), while the rest of Europe, including Italy, is still oriented towards the IF model.

The theoretical literature on ATM pricing has shown that an interchange fee regime (where banks jointly agree on a fee) may reduce price transparency and incentivize collusive behavior of banks at the wholesale level to relax price competition at the retail level (Donze and Dubec, 2006).

With reference to the DAF model, on the other hand, the main advantage is that the pricing is more consistent with the costs of offering the service and that it favors an explicit tariff policy.[6] This characteristic can also stimulate the supply of services through independent ATMs which - compared to traditional bank ATMs - rely less on cross-subsidization of services and can recover costs through explicit charges.[7]

However, there are also potential drawbacks. In particular, the application of an explicit tariff (or surcharge) to the customer can make the service more expensive (or perceived as such by customers). This may also apply if the new rate coincides with that applied by the issuing bank for foreign withdrawals. The information given to customers about the amount of the "surcharge" or "direct charge" at the time of the operation can in fact discourage them from continuing with the withdrawal. A case study is the Australian ATM market, which in 2009 adopted the DAF and saw a sharp drop in ATM withdrawals at the same cost for users (Flood and Mitchell, 2016).

---

[6] Studies have also shown that surcharging has a positive effect on the number of ATMs deployed in the market and an ambiguous effect on consumer welfare depending on travel costs and the availability of ATMs to consumers (Donze and Dubec, 2009; Chioveanu *et al.*, 2009; Knittel and Stango, 2008). If travel costs are high and the shopping space is less concentrated, consumers benefit more from a larger deployment of ATMs despite a more aggressive pricing policy on the side of banks. However, a larger network of ATMs in an environment with surcharges has also been associated with lower profits for banks because of the higher deployment costs (Donze and Dubec, 2009; Massoud and Bernhardt, 2002). Another interesting result is found in the literature on the interactions between the withdrawal market and the deposit market (Massoud, Saunders and Scholnick, 2006; Ishii, 2006; Knittel and Stango, 2011). This literature finds that high ATM fees degrade the value of competitors' deposit accounts, and have the potential to attract depositors away from competitors and segment the deposit market.

[7] In Germany, non-bank ATM service providers have pointed out to the German antitrust the anti-competitive nature of IF-based models imposed by international circuits to discourage the profitability of cash distribution services.

3. The profitability of ATMs in Italy and Europe

In this section, we use the information provided by the Centre for European Policy Studies (CEPS) in its latest report on the ATM industry in Europe (CEPS, 2018)[8] to conduct an international comparison on the profitability of the ATM business in a number of European countries. The CEPS Report assesses the current situation for ATM business models across the EU and the vulnerability to the ongoing digitalization. The various business models in the EU ATM market are identified, focusing on eight EU member states in particular, including Belgium, France, Germany, Greece, Poland, Portugal, Spain and Sweden. Moreover, for each of the business models the report identifies the ATM locations and their characteristics. Finally, the revenue streams and cost structures of the various business models and their drivers across the eight EU member states are estimated based on actual verifiable data, using official statistics and extrapolation of information from a wide range of public and private sources, including insights of various industry experts. The costs factors have been subdivided in two sub-categories: installation costs and operational costs. The installation costs are fixed in nature and depreciated over the lifetime of the ATM machine. The operational costs are either fixed or variable in nature. The fixed operating costs include mostly monthly or annual payments for real estate, communication and monitoring. The variable operating costs include costs that depend on the number of transactions that the ATM processes.

For Italy, we used data from the Survey on the Cost of Payment Services 2016.[9] The Survey is focused on the cost incurred for the supply/use of payment services by the participants in the payment value chain according to a methodology set by the Eurosystem: banks and other payment service providers, retailers, and public service companies. The data are compiled and illustrated separately for the various payment instruments (i.e. cards, credit transfers, checks, etc.) including cash services provided by the banks and infrastructures. As regard the cash services (as well as other payment services provided by banks), the data on costs (and output) are collected through ad hoc questionnaire involving a

[8] De Groen, Kilhoffer and Musmeci (2018).

[9] Banca d'Italia (2020).

representative sample of around 70 per cent of the market in payment services, comprising the main leading banking and financial groups, including Bancoposta. Industrial costs are collected by the banks according the ABC (activity based cost) method, and cash services costs are allocated through different cost items: collection and transportation of cash, withdrawals and deposits of cash, of which from an ATM, over the counter, safe-keeping handling, management and monitoring activities, procedures for false notes, customer services, and other. The survey considers both direct and indirect production costs. Direct costs are the costs "directly related" to the activities carried out for each payment instrument or cash services that have been imputed in a direct/straightforward way (e.g. costs associated with fees and commissions and with staff directly involved in each activity). Indirect costs are the costs associated with the supporting functions that are necessary to carry out the activities involved in each payment instrument and have been imputed using specific allocation keys (e.g. costs associated with rent, maintenance and depreciations, and with staff involved in supporting functions, such as overall management).

a. Costs and revenues

In Italy, the average cost of a cash transaction for the bank on the withdrawal side (including also the ones at the traditional counter) is higher than 2 euro. The cost of ATM withdrawals is just under half (0.90 euro[10]). This figure is roughly comparable with CEPS (2018) data on other European countries (Figure 1, and Appendix n. 2). The cost increases for "remote" or "standalone" ATMs as handling costs and operational risks rise.

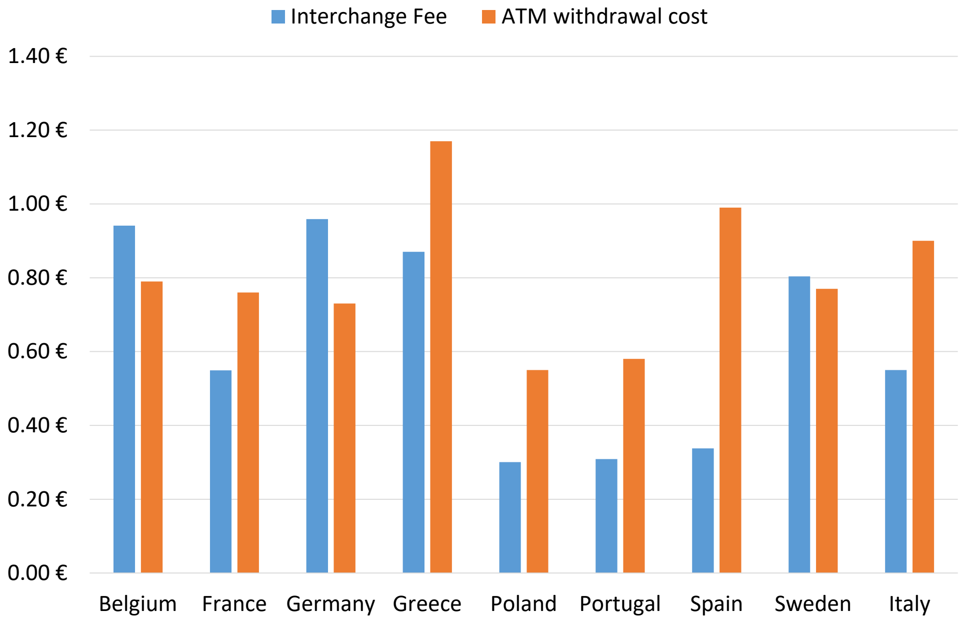
With reference to the cost structure, the share of variable costs is higher (70%). Variable costs are mainly linked to cash handling and transaction processing activities, and reduce the possibility of exploiting economies of scale as the size of the business increases.

It follows therefore that the unit costs for ATM operations of large banks are not very different from those incurred by smaller banks. If we compare the interchange fee with the unit costs on the

[10] This estimate is based on confidential data used in Banca d'Italia (2020), and corresponds to the industrial cost of an ATM withdrawal on the acquiring side based on cash-in and cash-out operations for both on-us and not-on-us withdrawals. It excludes issuance costs and indirect costs associated with maintaining the current account that amount to over a third of the overall cost, which is estimated at 1.50 euro per ATM withdrawal (see Banca d'Italia (2020), pp. 26-27).

ATM acquiring side in the different countries (Figure 1), we observe that in most cases it does not compensate for the cost of the withdrawal.

Figure 1: ATM unit cost of withdrawal and interchange fee



Notes and sources: CEPS (2018) and Banca d'Italia (2020).

With regard to revenues for the issuer, in Italy the effective average commission applied to the cardholder for not-on-us withdrawals (so-called disloyalty fee or foreign fee) is approximately 0.8 euro.[11] This estimate includes fees from intermediaries who do not apply explicit commissions or include them in the costs of the current account (bundling), as is the case, for example, for online banks. If we look at the distribution by commission classes, most of the issuing banks (70%) apply a disloyalty fee that does not exceed 2 euro per transaction, 20% of intermediaries charge commissions lower than or equal to 0.50 euro on average; among these, online banks are particularly relevant.

In terms of revenues for the acquirer, it is necessary to distinguish the multilateral interchange fee from other ATM revenues (e.g. dynamic currency conversion fee - DCC, surcharge fee or DAF, commissions for cash payments, advertising revenues, revenues for payment transactions, revenues for services provided on terminals managed by the merchant).

[11] Based on data on not-on-us withdrawals revenues and volumes for the period 2015-2020 extracted from the Banca d'Italia Regulatory Filings. See Section C.

The interchange fee for cash withdrawals is paid to the acquirer by the card issuer: within the Bancomat circuit this amounts to 0.49 euro per transaction based on the commitments of the scheme accepted by the Italian Competition Authority, while the interchange fees of the other card schemes (Mastercard and Visa) fluctuate around 0.50 euro for debit and prepaid cards.[12]

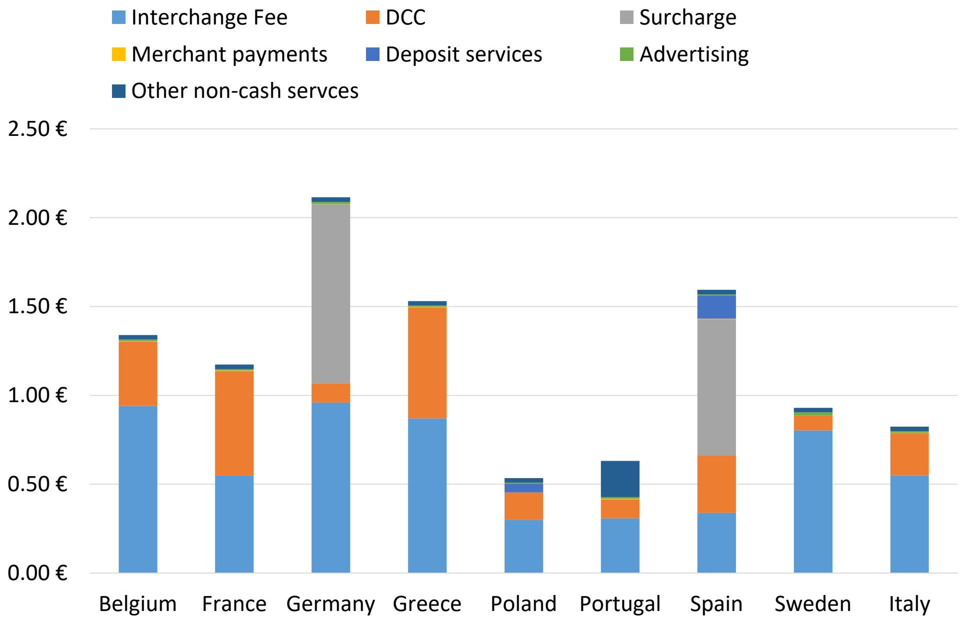
Figure 2 shows the different types of revenue received by the acquirer: interchange fee, surcharge fee (or DAF) and currency conversion fee (DCC) paid by the customer, advertising revenues from commercial providers, other commission revenues (e.g. for payment services, cash deposit).

There is a strong heterogeneity both in the levels and in the composition of the revenues. On the one hand there are countries such as Germany, Spain and Greece with higher profitability (between 1.5 to 2 euro per transaction) also thanks to the revenues from surcharges (DAF, especially in Germany and Spain), which are added to those from interchange fees or currency conversion (in countries such as Greece with a high tourist flow). On the other hand, there are countries, including Italy, where revenues from ATMs appear to be more contained for the acquirer, with levels well below 1 euro per transaction.[13]

[12] The data is based on nominal values disseminated by international circuits, expressed in terms of percentage commission, taking into account both consumer and business debit and prepaid cards and an average amount withdrawn between 150 and 200 euro per operation.

[13] The estimate for Italy is calculated using confidential data from Banca d'Italia (2020).

Figure 2: Revenue breakdown

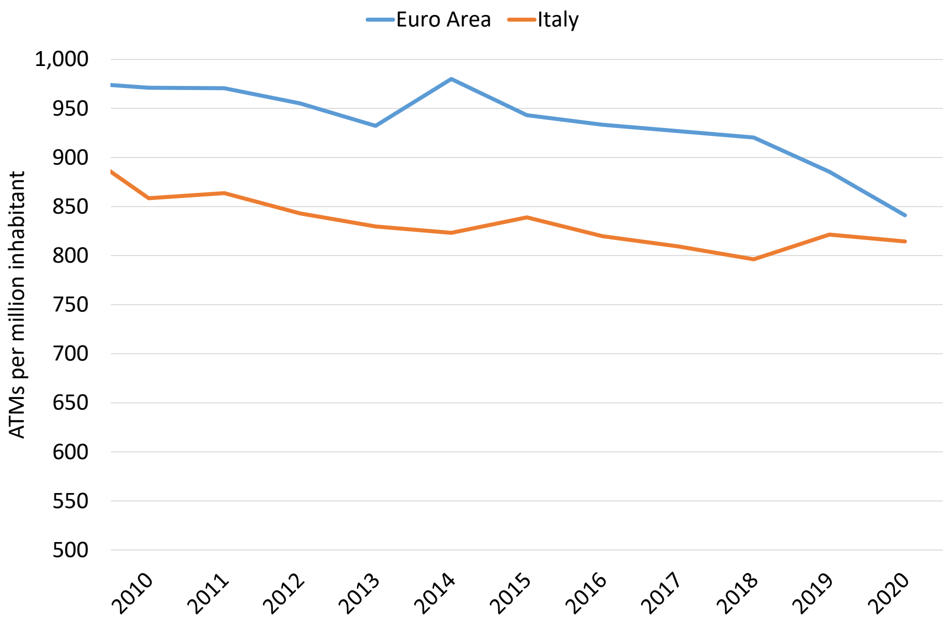


Notes and sources: CEPS (2018) and Banca d'Italia (2020).

b. ATM availability

In Italy there were 814 ATMs per million inhabitants in 2020 (821 in 2019), just below the European average of 841 (885 in 2019). As shown in Figure 3, the number of ATMs per inhabitant has decreased in the last ten years both in the euro area (-1.4% per year) and in Italy (-0.5% per year).

Figure 3: ATM availability



Notes and sources: ECB Statistical Data Warehouse.

According to the latest study on the payment attitudes of consumers in the euro area conducted by the ECB (SPACE, 2019), in Italy the average withdrawal is relatively high (116 euro compared to 88 euro in the euro area). Italian consumers reported a high level of satisfaction with their access to cash via ATMs, bank branches and post offices, in line with the average European consumer. However, at a European level, there has been a decline in the ease of access to consumers (down to 89% from 94% in the 2016 results of the survey).

c. ATM fees and withdrawals in Italy

According to the Banca d'Italia Regulatory Filings, during the years 2015-2020, Italian banks reported on average between 0.5 and 0.8 million not-on-us withdrawals per semester, and between 1.4 and 1.9 million on-us withdrawals. Therefore, in Italy the share of not-on-us ATM transactions is around a quarter of total ATM withdrawals. This share is higher for small and medium-sized banks or banks that do not hold their own ATM network (online banks reach 100% of "not-on-us" transactions).

Table 1: ATM fees and withdrawals in Italy

	Average not-on-us fee[1] €	Average not-on-us fee €	Average volumes not-on-us #	Average volumes on-us #	Average withdrawal not-on-us €	Average withdrawal on-us €
2015h1	0.72	0.67	504,027	1,475,135	132.43	208.42
2015h2	0.83	0.78	560,584	1,656,784	134.50	213.91
2016h1	0.81	0.74	524,787	1,627,215	130.77	208.74
2016h2	0.76	0.76	628,853	1,774,879	134.68	215.23
2017h1	0.68	0.68	712,708	1,917,345	135.69	210.57
2017h2	0.74	0.73	765,853	1,921,681	139.42	219.17
2018h1	0.77	0.75	724,748	1,843,568	135.74	215.46
2018h2	0.84	0.83	776,809	1,895,070	138.94	223.94
2019h1	0.84	0.82	707,247	1,849,056	136.95	219.74
2019h2	0.79	0.78	764,726	1,928,071	140.30	227.85
2020h1	0.77	0.75	502,750	1,443,957	147.04	244.40
2020h2	0.79	0.78	608,587	1,677,768	150.21	250.70
2015-2020	0.78	0.76	643,147	1,743,281	137.87	220.75

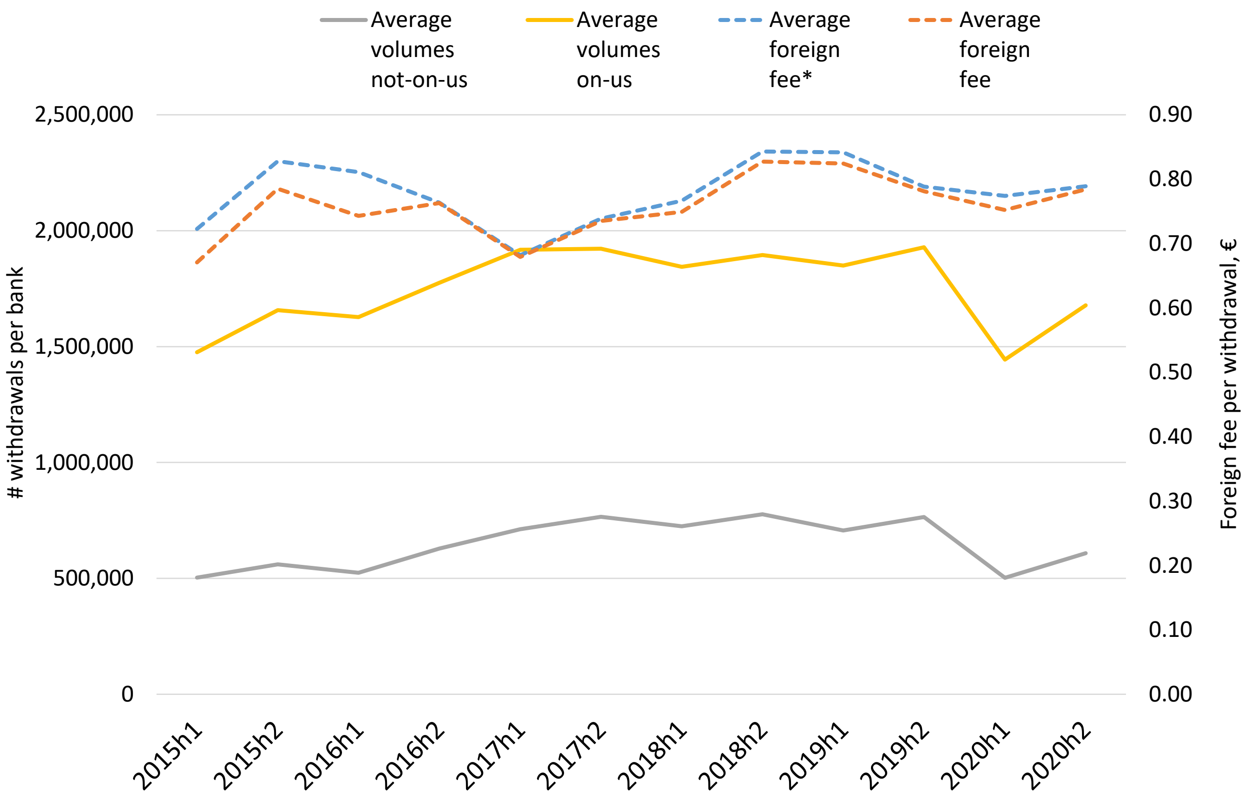
Notes and sources: 1: Includes Hadi (1994) outliers. Debit cards data by bank from Banca d'Italia, Regulatory Filings. Average not-on-us fees and withdrawals are weighted by not-on-us volumes. Average on-us withdrawals are weighted by on-us volumes.

We calculate not-on-us fees using data on revenues from not-on-us withdrawals and volumes of not-on-us withdrawals. This average excludes implicit fees from banks who include not-on-us ATM transactions in the costs of their customers' bank accounts as part of a bundle of services. We estimate that not-on-us fees averaged 0.76 euro in the period 2015-2020. The average not-on-us fee fluctuates between 0.67 and 0.83 euro per transaction in the same period, as reported in Table 1.[14]

The average number of withdrawals per bank grew steadily during 2015-2017 and remained constant in 2018 and 2019. In the first half of 2020, due to the restrictive measures put in place to contrast the Covid-19 outbreak, the number of withdrawals per bank dropped significantly (Figure 4). At the same time, the average amounts withdrawn both on-us and not-on-us increased (Figure 5). This increase has also been associated to precautionary motives in Italy as documented in Baldo *et al.* (2021). The average not-on-us amount withdrawn estimated using the Banca d'Italia Regulatory Filings appears to be slightly higher but substantially in line with the survey estimates of the ECB reported in SPACE (2019).

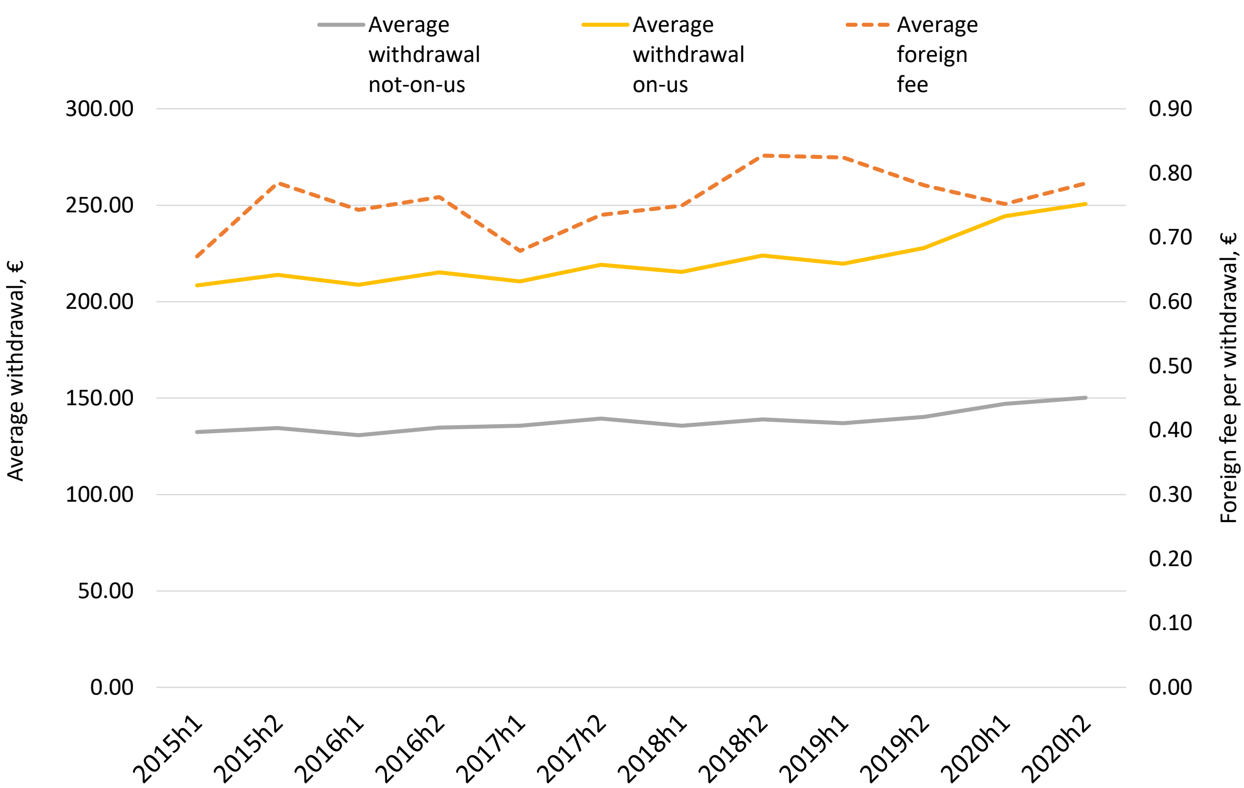
[14] Average fees are weighted by volumes of not-on-us withdrawals. We use the methodology developed by Hadi (1994) to remove multivariate outliers from the sample. The weighted average commission calculated including the outliers is comparable with the series that excludes the outliers as shown in Figure 4. This result derives from the fact that the outliers account for a small share of not-on-us volumes in each semester included in the sample (Appendix).

Figure 4: Average volumes of withdrawals and fees



Notes and sources: See notes to Table 1. * Includes Hadi (1994) outliers.

Figure 5: Average value of withdrawals and fees



Notes and sources: See notes to Table 1.

4. Price elasticity of ATM withdrawals

Empirical estimates of the price elasticity of ATM withdrawals are available in the economic literature that studies the interplay between the firms' investment and the consumers' usage decisions of new technologies, as well as studies on households' choice of retail payment instruments. Additional estimates come from analyses that evaluate the medium-run impact of the introduction of foreign fees or surcharges on the installation of new ATMs and the strategic implications concerning the deposit market. The studies surveyed estimate the price elasticity of ATM withdrawals to be between -0.13 and -0.50, indicating a substantial rigidity of the demand for ATM withdrawals.

Humphrey et al. (2001) estimates a price elasticity of ATM withdrawals of -0.50 using semi-annual data for the period 1989-2005 on two bank groups (savings and commercial banks) and a general model of payment choice.

Gowrisankaran and Krainer (2007) uses the exogenous variation in surcharging policies in two US states (Iowa and Minnesota) and, without using data on the actual ATM cash withdrawals, estimates that a price increase by ten cents lowers the probability of using a particular ATM from 50 percent to 45 percent. Evaluated at a mean price of 0.50 US dollars, this implies a price elasticity of -0.50, as explained in Ferrari, Verboven and Degryse (2010), who also finds a similar price elasticity using data from Belgium.

Knittel and Stango (2011) uses data on fees (foreign and surcharge) and number of withdrawals for the largest ATM card issuers in the United States during 1994-1999. Using an instrumental variable strategy, and including a parameter that captures the competitors' reaction in a residual demand framework, it exploits variation over time in surcharge adoption rates and estimates that a one-dollar increase in fees reduces foreign transactions per ATM machine by roughly 1,000 per month. The authors found that larger operators with more extensive withdrawal networks push to define high fees to segment the market and siphon depositors attracted by the possibility to withdraw cash without commissions from a more widespread ATM network.

Magnac (2017) evaluates the impact of foreign fees paid by consumers on their cash withdrawals, taking as given the economic environment such as ATM location and other banks' strategies. Using proprietary data on a random sample of 60,000 individual bank accounts observed over 28 months, it estimates the residual demand that the bank under study faces by considering other banks' behavior as fixed. Using a quasi-experimental framework (diff-in-diffs) it estimates a short run price elasticity of foreign ATM withdrawals between -0.13 and -0.18, and a long-run price elasticity between -0.18 and -0.25.

Karoubi (2013) uses aggregate payments and withdrawals data from clearing houses followed over 72 months in France during 2001-2007. It uses a natural experiment in which large banks adopted foreign fees around the European standard of 1 euro per withdrawal beyond a free allowance (5 or 6 per month). The author uses a before-after or structural break time-series methodology and estimates a price elasticity around -0.36.

To estimate the price elasticity of ATM withdrawals, we use semi-annual data from the Banca d'Italia Regulatory Filings on ATM withdrawals with debit card for a panel of around 240 Italian banks observed in the period 2015-2020. We consider banks who apply positive not-on-us fees. Our data allows us to investigate the relationship between not-on-us fees and both components of ATM withdrawals demand (not-on-us and on-us) as well as total demand (sum of not-on-us and on-us). To account for persistent patterns in the demand for cash, we express the market demand for ATM withdrawals using a log-linear relationship in a partial adjustment model with time and bank fixed effects:

$$Q_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 ATMs_{it} + \beta_3 Q_{it-1} + \beta_4 P_{it-1} + f_i + h_t + \varepsilon_{it} \qquad (1)$$

where Q_{it} represents the volume of withdrawals for bank i in semester t and P_{it} is the average foreign fee calculated as the ratio between not-on-us revenues and not-on-us withdrawals on the issue side. The bank fixed effects (f_i) take into account unobservable characteristics of banks that are potentially correlated with the independent variables and are assumed constant over time. The time fixed effects (h_t) take into account fluctuations in the general demand for withdrawals, which are assumed to affect all banks. We control for the ATM fleet of each bank ($ATMs_{it}$), which is available annually and expressed in log form in the model.

This specification might be affected by the endogeneity of fees with respect to the quantity demanded: the price and the demand for foreign ATM withdrawals are determined simultaneously in equilibrium, therefore shifts in the demand caused by independent exogenous shocks can determine new equilibrium prices, which means that prices are correlated with the stochastic component of the model. Similarly, the ATM fleet may have a simultaneity bias problem, as the number of ATMs deployed by a bank in each year is possibly correlated with unobserved factors that affect the demand for withdrawals.

Furthermore, we need to account for the dynamic panel bias introduced by the presence of the lag of volumes demanded among the explanatory variables (Nickell, 1981).

Since our dataset is a short unbalanced panel of around 240 banks observed over 12 semesters, a natural choice for estimating the parameters of interest is the GMM estimators developed by the literature on dynamic panel data, surveyed for example in Blundell, Bond and Windmeijer (2000), Arellano and Honore (2001), and Bond (2002).

Following the empirical literature on short panel econometrics, we estimate a level equation by OLS and a within group estimator to guide our expectations about the adjustment parameter and help us detect the presence of finite sample bias. The OLS and within estimates of the adjustment parameter are biased in opposite directions, so that a reasonable estimate of the adjustment parameter should lie within the range provided by the OLS estimator, which is biased upwards, and the within estimator, which is biased downwards (Bond, 2002).

To investigate the time series properties of our data, we estimate a simple AR1 model for volumes and fees (Table 2) and find that the difference GMM estimate of the autoregressive term appears to be biased towards the within estimator for all series, while the system GMM estimates are in the expected range. This finding suggests the presence of finite sample bias associated with highly persistent series, which has been shown to affect GMM difference estimates, but not GMM system estimates (Blundell, Bond and Windmeijer, 2000).

Table 2: AR1 specifications

	OLS levels	Within groups	GMM difference $(t-3)$	GMM system $(t-3)$
Not-on-us volumes				
coeff	0.923	0.437	0.202	0.682
robust s.e.	0.011	0.040	0.032	0.047
m1	4.78	2.72	-1.79	-3.59
m2	6.04	-0.90	4.52	3.19
On-us volumes				
coeff	0.937	0.523	0.315	0.540
robust s.e.	0.011	0.051	0.034	0.072
m1	4.96	2.04	-1.33	-2.04
m2	5.28	-0.87	1.25	0.03
Total volumes				
coeff	0.928	0.453	0.288	0.592
robust s.e.	0.011	0.042	0.026	0.047
m1	5.32	2.21	-0.97	-2.09
m2	7.06	-0.59	3.27	1.78
Fees				
coeff	0.900	0.277	0.005	0.562
robust s.e.	0.019	0.071	0.119	0.074
m1	-4.54	-2.12	-3.53	-2.53
m2	4.82	3.42	2.76	2.18

Notes: Results from first order autoregressive models for each variable. Test statistics for first and second order autocorrelation of the residuals (Arellano-Bond test) are reported below the robust standard errors.

In particular, the instruments available for the equations in first-differences are likely to be weak when the individual series have near unit root properties like in our data (OLS estimates of the adjustment parameter are around 0.9). Instrumental variable estimators can be subject to serious finite sample biases when the instruments used are weak. By contrast, the system GMM estimator, which requires that the bank-level effects be uncorrelated with the first difference of the first observation of the dependent variable, has much smaller finite sample bias and greater precision when estimating autoregressive parameters using persistent series.[15]

[15] See Arellano and Bover (1995), Blundell and Bond (1998).

Therefore, we estimate the multivariate model specified in equation (1) using a system GMM estimator, where fees and ATM fleet are treated as endogenous and instrumented using $t-3$ lags. The estimation results for not-on-us withdrawals are presented in Table 3. We report the results from OLS, within group, and difference GMM for a comparison.

Table 3: Not-on-us withdrawals (volume)

		(1) OLS levels	(2) Within	(3) GMM diff $(t-3)$	(4) GMM sys $(t-3)$
Q_{t-1}	β_3	0.7943***	0.3683***	0.2812***	0.4995**
		(0.0298)	(0.0470)	(0.0334)	(0.2287)
P_{t-1}	β_4	0.1211**	0.0143	-0.0491*	-0.0969
		(0.0482)	(0.0256)	(0.0290)	(0.3905)
$ATMs_t$	β_2	0.2146***	0.4764***	0.1184	0.7333**
		(0.0335)	(0.1305)	(0.2766)	(0.2979)
Short run elasticity					
P_t	β_1	-0.2384***	-0.2222***	-0.1620***	-0.2513
		(0.0476)	(0.0629)	(0.0606)	(0.2623)
Long run elasticity					
$(\beta_1 + \beta_4)/(1-\beta_3)$		-0.5703***	-0.3291***	-0.2938***	-0.6957**
		(0.0528)	(0.0930)	(0.1031)	(0.3446)
R^2		0.96	0.54		
Observations		1,650	1,650	1,410	1,650
Panels			243	225	243
Time effects		Yes	Yes	Yes	Yes
Number of instruments				181	215
m1 (p-values)				0.0110	0.0498
m2 (p-values)				0.7779	0.9193
Sargan (p-values)				0.1317	0.3532
Diff. Sargan (p-values)					0.9679

Notes: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses, Arellano-Bond robust standard errors below the difference GMM estimates, Windmeijer corrected robust standard errors below the system GMM estimates. Standard errors for the long run elasticity are derived with the delta method. All variables are expressed in logs. Columns 3 and 4 report the estimates from one-step difference and two-step system GMM, where all independent variables are treated as endogenous and instrumented using $t-3$ lags. Below these, we report the p-values of the Arellano and Bond test for first (m1) and second (m2) order autocorrelation of the residuals and the p-values of the Sargan test for overidentifying restrictions obtained from a two-step estimator. Below the system GMM estimates, we report the p-value resulting from a difference in Sargan test for the validity of the additional moment conditions in the system GMM model.

Reading from the last column, the coefficient of the adjustment parameter is below the OLS estimate and above the within group estimate which confirms the validity of the system GMM model. The Arellano and Bond tests for the presence of second order autocorrelation as well as the Sargan and difference in Sargan tests for overidentifying restrictions are both passed. We use the estimated coefficients on fees and the adjustment parameter to calculate the short and long run price elasticities of the demand for not-on-us ATM withdrawals. We estimate a short run price elasticity between -0.16 and -0.25, which is in the range provided by past studies, and statistically significant in all models except the system GMM. By dividing the sum of the coefficients for not-on-us fees by one minus the coefficient on the adjustment parameter, we obtain an estimate of the long run elasticity of -0.70, which is statistically significant and larger in magnitude than the short-run elasticity consistently with demand theory. We interpret the long run elasticity in terms of the equilibrium of the withdrawals market as measured by the adjustment parameter, which is estimated at 0.50.[16] This means that half of the adjustment to the demand for not-on-us withdrawals takes place in the current semester, which implies that the withdrawals demand fully adjusts in two semesters that is therefore what we take as "long run" horizon.

Put differently, the estimation results suggest that, when the unit price of not-on-us withdrawals increases, the demand for not-on-us withdrawals continues to decrease over time and reaches a new equilibrium within two semesters. This dynamic makes sense if we think that consumers need time to change their withdrawal habits (if not, more generally, payment habits).

As all the estimated elasticities are below unity, we interpret this as evidence of a substantial rigidity of demand, which is in line with previous studies.

[16] We focus on the results of the system GMM model, as the estimates of the adjustment parameter are biased in the other models.

Table 4: Total withdrawals (volume)

		(1) OLS levels	(2) Within	(3) GMM diff $(t-3)$	(4) GMM sys $(t-3)$
Q_{t-1}	β_3	0.7829***	0.3936***	0.3115***	0.5257***
		(0.0363)	(0.0587)	(0.0201)	(0.1984)
P_{t-1}	β_4	-0.0027	-0.0068	-0.0309	-0.0888
		(0.0375)	(0.0137)	(0.0210)	(0.3266)
$ATMs_t$	β_2	0.2323***	0.4305***	0.1817	0.5988*
		(0.0412)	(0.1301)	(0.1688)	(0.3226)
Short run elasticity					
P_t	β_1	-0.0329	-0.0318*	-0.0127	-0.0875
		(0.0365)	(0.0176)	(0.0174)	(0.1647)
Long run elasticity					
$(\beta_1 + \beta_4)/(1-\beta_3)$		-0.1642***	-0.0636**	-0.0633	-0.3718
		(0.0485)	(0.0301)	(0.0399)	(0.3883)
R^2		0.97	0.59		
Observations		1,650	1,650	1,410	1,650
Panels			243	225	243
Time effects		Yes	Yes	Yes	Yes
Number of instruments				181	215
m1 (p-values)				0.4381	0.0044
m2 (p-values)				0.5827	0.9824
Sargan (p-values)				0.2787	0.4916
Diff. Sargan (p-values)					0.9110

Notes: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses. See notes to Table 3.

A similar analysis having the total demand for withdrawals (sum of not-on-us and on-us) as the dependent variable results in an elasticity not significantly different from zero and substantially lower in magnitude (Table 4), both in the short run (-0.09) and in the long run (-0.37).

These coefficients suggest a higher rigidity of the total demand for withdrawals compared to not-on-us withdrawals. If on the one hand this is consistent with the fact that not-on-us withdrawals are only a quarter of total withdrawals in the sample (Table 1), on the other hand it is also possible to hypothesize a shift of consumers towards on-us withdrawals.

This hypothesis is confirmed if we use on-us withdrawals as the dependent variable (Table 5).

Table 5: On-us withdrawals (volume)

		(1) OLS levels	(2) Within	(3) GMM diff $(t-3)$	(4) GMM sys $(t-3)$
Q_{t-1}	β_3	0.7609***	0.4758***	0.4297***	0.4895***
		(0.0355)	(0.0502)	(0.0535)	(0.1823)
P_{t-1}	β_4	-0.0474	0.0024	-0.0028	-0.0315
		(0.0320)	(0.0259)	(0.0327)	(0.1823)
$ATMs_t$	β_2	0.2723***	0.3185***	0.0815	0.5487*
		(0.0426)	(0.1122)	(0.2039)	(0.3155)
Short run elasticity					
P_t	β_1	0.1070***	0.1209*	0.1113	0.1309
		(0.0319)	(0.0689)	(0.0720)	(0.2241)
Long run elasticity					
$(\beta_1 + \beta_4)/(1-\beta_3)$		0.2494***	0.2352*	0.1904	0.1946
		(0.0492)	(0.1287)	(0.1353)	(0.3577)
R^2		0.97	0.61		
Observations		1,621	1,621	1,385	1,621
Panels			240	222	240
Time effects		Yes	Yes	Yes	Yes
Number of instruments				181	215
m1 (p-values)				0.1300	0.1881
m2 (p-values)				0.5578	0.8088
Sargan (p-values)				0.1852	0.4978
Diff. Sargan (p-values)					0.9923

Notes: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses. See notes to Table 3.

Since on-us withdrawals are free of charge, the elasticities to not-on-us fees can be interpreted as cross-price elasticities. The estimated cross-price elasticities are positive in all specifications, but are not statistically significant in the GMM models. Despite the low significance, we view the estimated signs of the short and long run elasticities as evidence of a certain degree of substitutability of not-on-us withdrawals with on-us withdrawals. This also provides an explanation for the higher rigidity of the total demand for withdrawals compared to its not-on-us component.

We also investigated the price elasticities of ATM withdrawals demand expressed in euro and we obtained nearly identical elasticities (Appendix, n. 2). This is likely due to the stability of the average amount withdrawn for both on-us and not-on-us withdrawals, as shown in Figure 5. To confirm this, we also analyzed the relationship between fees and average amount withdrawn and found no significant impact of fees on both on-us and not-on-us average amounts withdrawn.[17] As an additional robustness check, we also estimated a model that includes the average value of card transactions or a time varying indicator that measures the banks' customers' preference for electronic payments as additional control variables and found no significant impact on our estimates.[18]

5. Conclusion

Despite the growth of card payments and electronic payments through remote digital channels, recently also pushed by the restrictive measures adopted to contrast the Covid-19 pandemic, the demand for cash withdrawal services has continued to be sustained in Italy, not only for transactional purposes, but also for precautionary motives.

The ATM network therefore remains a crucial infrastructure for guaranteeing the access to cash to consumers in an interoperable regime. We analyzed the main business models in the Italian ATM market in comparison to other European countries and found that the current (interchange fee) model - based in part on cross-subsidies - may not guarantee its future sustainability in the absence of adequate cost coverage. As ATM operators consider reviewing their pricing and business models, it is important to understand how market demand might react to price changes.

Using data on fees and withdrawals from a panel of Italian banks in 2015-2020, we estimate the elasticity of demand for cash withdrawals to not-on-us (or "foreign") fees, which are fees paid by consumers when they withdraw cash at banks that are not their own.

Using a partial adjustment model, we estimate a short run elasticity between -0.16 and -0.25 and a long run price elasticity of not-on-us withdrawals of -0.70. We find that total withdrawals are substantially rigid to not-on-us fees with an estimated long run elasticity of -0.37 and not statistically significant, due in part to the shift of consumers to on-us withdrawals, i.e. withdrawals from their own bank. Using the

[17] We investigated this relationship using a static model with bank and time fixed effects as well as a dynamic panel data model.

[18] As a measure of the preference for electronic payments, we used a cash-card ratio defined as the share of total ATM withdrawals over the sum of total ATM and card transactions carried out with debit cards.

same analytical framework, we find that the cross-price elasticity for on-us withdrawals is in fact positive although not significant in our preferred specification.

We would like to highlight a number of caveats to the interpretation of our results.

From our reduced form analysis, it is not possible to determine how consumers could react to a different communication scheme that makes the cost associated with the not-on-us withdrawal explicit at the time of withdrawal, nor if a change in the business model could cause a shock to consumer preferences towards electronic payments. The substitutability between cash and electronic payments is a key factor affecting the ATM industry globally, and has been widely documented. Furthermore, an increase in ATM fees could encourage greater use of the POS network for withdrawals (so-called "cash in shop"), especially by customers of smaller banks or online banks, to the extent that the withdrawal fee applied at the physical point of sale is more advantageous than that at the ATM.

It is also difficult to establish *a priori* whether a change in the business model could have repercussions on the degree of competition in the deposit market, due to anti-competitive behavior on the part of banks in relation to their market share. As described in the economic literature, intermediaries with a wider network of ATMs would tend to charge higher fees to attract depositors from competing banks.

In addition, it should be considered that the potentially higher profits generated by an increase in prices could also attract more investments in the cash distribution sector. This could potentially improve the quality of the service and increase the overall availability of ATMs in the territory, which has been associated in the literature with higher consumer welfare and ambiguous profit gains for banks depending on ATM deployment costs.

Despite these limitations, our empirical analysis can provide useful insights for evaluating tariff reforms that entail an increase of not-on-us fees. We show that an increase in not-on-us fees would affect the not-on-us component of the demand for ATM withdrawals, but not necessarily lead to a reduction in the overall demand, also due to a possible shift of consumers towards on-us withdrawals.

References

Ardizzi, G., A. Nobili and G. Rocco (2020), "A game changer in payment habits: evidence from daily data during a pandemic", Banca d'Italia, Occasional Papers, no. 591.

Arellano, M. and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", The Review of Economic Studies, vol. 58, no. 2, pp. 277-297.

Arellano, M. and O. Bover (1995), "Another look at the instrumental variable estimation of error-components models", Journal of Econometrics, 68: 29-51.

Arellano, M. and B. Honore (2001), "Panel data models: some recent developments", in: Heckman J.J., Leamer E.E. (eds), Handbook of econometrics, Vol. 5, North-Holland, Amsterdam.

Baldo, L., E. Bonifacio, M. Brandi, M. Lo Russo, G. Maddaloni, A. Nobili, G. Rocco, G. Sene and M. Valentini (2021), "Inside the black box: tools for understanding cash circulation", Banca d'Italia, Markets, Infrastructures, Payment Systems.

Banca d'Italia (2020), "The social cost of payment instruments in Italy - The results of the second survey", Institutional Issues.

Blundell, R.W. and S. Bond (1998), "Initial conditions and moment restrictions in dynamic panel data models", Journal of Econometrics, 87: 115-143.

Blundell, R.W., S. Bond and F. Windmeijer (2000), "Estimation in dynamic panel data models: improving on the performance of the standard GMM estimator", in: Baltagi B. (ed.), Advances in econometrics, Vol 15. Nonstationary panels, panel cointegration, and dynamic panels, JAI Elsevier, Amsterdam.

Bond, S. (2002), "Dynamic panel data models: a guide to micro data methods and practice", Portuguese Economic Journal, 1, 141-162.

Chioveanu, T., R. Fauli-Oller, J. Sandonis and J. Santamaria (2009), "ATM Surcharges: Effects on Deployment and Welfare", The Journal of Industrial Economics, vol. 57, no. 3, pp. 583-612.

De Groen, W.P., Z. Kilhoffer and R. Musmeci (2018), "The Future of EU ATM Markets: Impacts of digitalisation and pricing policies on business models", Centre for European Policy Studies (CEPS).

Donze, J. and I. Dubec (2006), "The Role of interchange fee in ATM networks", International Journal of Industrial Organizations, 24 (1): 29-43.

Donze, J. and I. Dubec (2009), "Paying for ATM Usage: Good for Consumers, Bad for Banks?", The Journal of Industrial Economics, vol. 57, no. 3, pp. 583-612.

European Central Bank (2020), "Study on the payment attitudes of consumers in the euro area (SPACE)".

Ferrari, S., F. Verboven and H. Degryse (2010), "Investment and Usage of New Technologies: Evidence from a Shared ATM Network", The American Economic Review, 100, no. 3, pp. 1046-079.

Flood, D. and S. Mitchell (2016), "The ATM System since the 2009 Reforms", RBA Bulletin, March Quarter.

Hadi, A. (1994), "A Modification of a Method for the Detection of Outliers in Multivariate Samples", Journal of the Royal Statistical Society, Series B (Methodological), 56, no. 2, pp. 393-96.

Humphrey, D. B., M. Kim, and B. Vale (2001), "Realizing the gains from electronic payments: Costs, pricing, and payment choice", Journal of Money, Credit and Banking, 216-234.

Ishii, J. (2006), "Interconnection Pricing, Compatibility, and Investment in Network Industries: ATM Networks in the Banking Industry", Working Paper, Stanford University.

Knittel, C. and V. Stango (2008), "Incompatibility, Product Attributes and Consumer Welfare: Evidence from ATM's", BE Journal of Economic Analysis and Policy, vol. 8, issue 1.

Knittel, C. and V. Stango (2011), "Strategic Incompatibility in ATM Markets", Journal of Banking and Finance, vol. 35, no. 10, pp. 2627-2636.

Massoud, N. and D. Bernhardt (2002), "Rip-off ATM Surcharges", Rand Journal of Economics, 33, pp. 96-115.

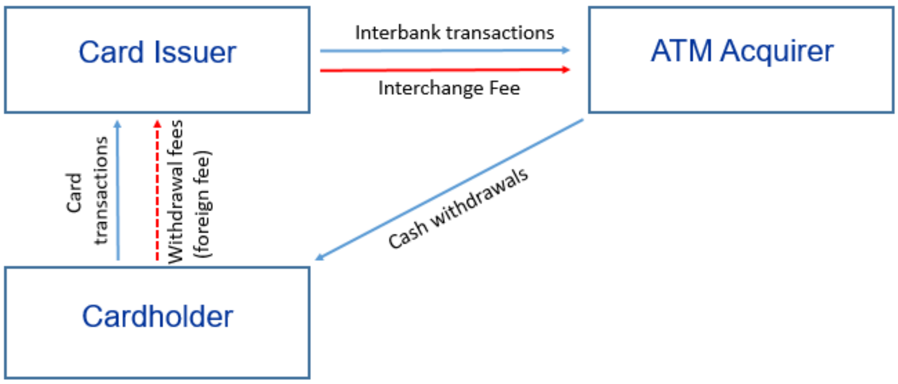
Massoud, N., A. Sanders and B. Scholnick (2006), "The Impact of ATM Surcharges on Large versus Small Banks: Is There a Switching Effect?", The Journal of Business, 79(4), pp. 2099-2125.

Nickell, S. (1981), "Biases in Dynamic Models with Fixed Effects", Econometrica, vol. 49, no. 6, pp. 1417-1426.

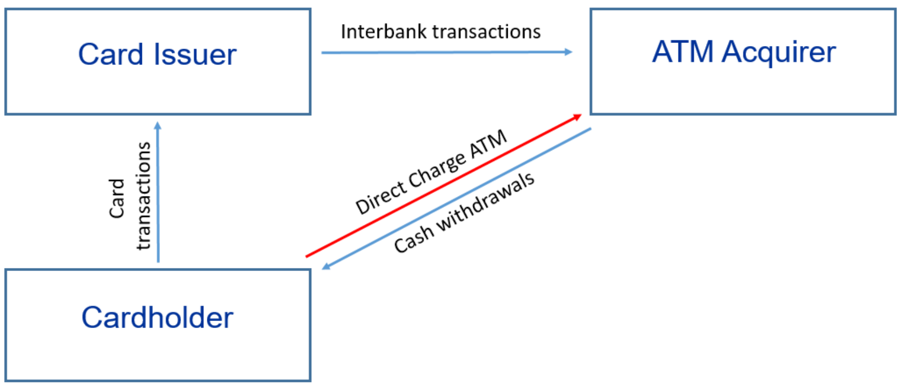
Appendix

1. ATM pricing models

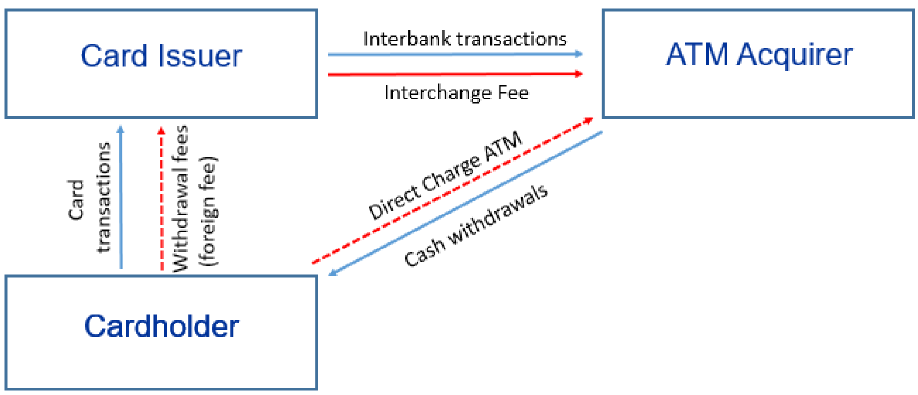
Interchange Fee ATM model



Direct Access Fee (DAF)



Surcharge & Interchange fee ATM model



2. Further results

Table A1: Outliers

	Number of intermediaries \#	Number of excluded intermediaries (outliers) \#	Average volume *not-on-us* excluded \#	% volume *not-on-us* excluded %
2015h1	240	6	11,735	2.3%
2015h2	225	6	9,343	1.6%
2016h1	219	8	8,567	1.6%
2016h2	212	4	327	0.1%
2017h1	190	12	101	0.0%
2017h2	192	21	60	0.0%
2018h1	194	25	364	0.1%
2018h2	195	26	368	0.0%
2019h1	193	24	394	0.1%
2019h2	191	24	151	0.0%
2020h1	191	25	249	0.0%
2020h2	189	22	74	0.0%

Notes and sources: Debit cards data by bank from Banca d'Italia, Regulatory Filings.

Table A2: Unit costs by business model

	Installation €/transaction	Variable €/transaction	Fixed €/transaction	Total €/transaction
Bank branches				
Mean	0.11	0.53	0.04	0.69
Median	0.09	0.53	0.05	0.70
Min	0.07	0.19	0.02	0.30
Max	0.20	0.87	0.08	0.97
Bank remote				
Mean	0.10	0.69	0.18	0.97
Median	0.08	0.73	0.12	1.06
Min	0.05	0.22	0.07	0.37
Max	0.19	1.09	0.56	1.43
Independent				
Mean	0.12	0.88	0.31	1.31
Median	0.12	0.82	0.23	1.01
Min	0.03	0.24	0.12	0.69
Max	0.22	2.08	0.84	2.58
All models				
Mean	0.11	0.70	0.18	0.99
Median	0.09	0.63	0.11	0.96
Min	0.03	0.19	0.02	0.30
Max	0.22	2.08	0.84	2.58

Notes and sources: calculations based on data from CEPS (2018).

Table A3: Weighted average withdrawal cost breakdown

	Unit Cost cent. €/transaction	Unit Cost % share
Installation costs	**9.28**	**10.37%**
Site finding and contracting costs	0.05	0.05%
ATM dismantling	0.43	0.48%
ATM installation	2.90	3.25%
ATM machine	5.90	6.60%
Variable costs	**66.25**	**74.06%**
Consumables	0.09	0.10%
Maintenance	3.96	4.43%
Physical cost of cash/cash processing	5.27	5.90%
Cash filling	6.93	7.75%
Financing costs	16.61	18.57%
Processing costs (card schemes)	33.38	37.32%
Fixed costs	**13.93**	**15.57%**
Taxation	0.09	0.10%
Insurance	0.31	0.34%
Monitoring cost, cash forecasting, cash reconciliation, chargeback handling	0.91	1.02%
Communication	1.17	1.31%
Security	1.54	1.72%
Real estate (site rent)	9.90	11.07%
Weighted average total cost	**89.46**	**100.0%**

Notes and sources: calculations based on data from CEPS (2018).

Table A4: Not-on-us withdrawals (value)

		(1) OLS levels	(2) Within	(3) GMM diff $(t-3)$	(4) GMM sys $(t-3)$
Q_{t-1}	β_3	0.7958***	0.3639**	0.2741***	0.4999**
		(0.0285)	(0.0440)	(0.0353)	(0.2382)
P_{t-1}	β_4	0.1172**	0.0091	-0.0464	-0.0902
		(0.0459)	(0.0231)	(0.0286)	(0.3851)
$ATMs_t$	β_2	0.2074***	0.5164**	0.1108	0.7035**
		(0.0316)	(0.1250)	(0.2817)	(0.3108)
Short run elasticity					
P_t	β_1	-0.2335***	-0.2189**	-0.1676***	-0.2579
		(0.0448)	(0.0613)	(0.0601)	(0.1981)
Long run elasticity					
$(\beta_1 + \beta_4)/(1-\beta_3)$		-0.5699***	-0.3299**	-0.2949***	-0.6960*
		(0.0530)	(0.0944)	(0.1009)	(0.4143)
R^2		0.96	0.54		
Observations		1,649	1,649	1,409	1,649
Panels			243	225	243
Time effects		Yes	Yes	Yes	Yes
Number of instruments				181	215
m1 (p-values)				0.0231	0.0789
m2 (p-values)				0.1840	0.7914
Sargan (p-values)				0.1421	0.3052
Diff. Sargan (p-values)					0.8960

Notes: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses. See notes to Table 3.

Table A5: Total withdrawals (value)

		(1) OLS levels	(2) Within	(3) GMM diff $(t-3)$	(4) GMM sys $(t-3)$
Q_{t-1}	β_3	0.7775***	0.3771***	0.2960***	0.5312**
		(0.0354)	(0.0541)	(0.0264)	(0.2482)
P_{t-1}	β_4	-0.0109	-0.0112	-0.0268	-0.0889
		(0.0361)	(0.0120)	(0.0197)	(0.2835)
$ATMs_t$	β_2	0.2483***	0.4179***	0.0929	0.5962
		(0.0423)	(0.1295)	(0.1778)	(0.3904)
Short run elasticity					
P_t	β_1	-0.0254	-0.0260	-0.0020	-0.0869
		(0.0348)	(0.0161)	(0.0177)	(0.1504)
Long run elasticity					
$(\beta_1 + \beta_4)/(1-\beta_3)$		-0.1636***	-0.0597*	-0.0408	-0.3750
		(0.0481)	(0.0322)	(0.0394)	(0.5163)
R^2		0.97	0.58		
Observations		1,650	1,650	1,410	1,650
Panels			243	225	243
Time effects		Yes	Yes	Yes	Yes
Number of instruments				181	215
m1 (p-values)				0.6828	0.0121
m2 (p-values)				0.0483	0.7234
Sargan (p-values)				0.2114	0.4862
Diff. Sargan (p-values)					0.9762

Notes: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses. See notes to Table 3.

Table A6: On-us withdrawals (value)

		(1) OLS levels	(2) Within	(3) GMM diff $(t-3)$	(4) GMM sys $(t-3)$
Q_{t-1}	β_3	0.7046***	0.3809***	0.3253***	0.4054**
		(0.0490)	(0.0747)	(0.0762)	(0.1670)
P_{t-1}	β_4	-0.0488	0.0015	-0.0005	-0.0473
		(0.0311)	(0.0252)	(0.0337)	(0.1907)
$ATMs_t$	β_2	0.3602***	0.3396***	0.0148	0.6803***
		(0.0654)	(0.1229)	(0.2462)	(0.2620)
Short run elasticity					
P_t	β_1	0.1029***	0.1108**	0.1270*	0.1232
		(0.0314)	(0.0531)	(0.0716)	(0.2908)
Long run elasticity					
$(\beta_1 + \beta_4)/(1-\beta_3)$		0.1832***	0.1814**	0.1875	0.1276
		(0.0426)	(0.0916)	(0.1149)	(0.2724)
R^2		0.97	0.55		
Observations		1,621	1,621	1,385	1,621
Panels			240	222	240
Time effects		Yes	Yes	Yes	Yes
Number of instruments				181	215
m1 (p-values)				0.2579	0.2232
m2 (p-values)				0.6246	0.8910
Sargan (p-values)				0.2119	0.5388
Diff. Sargan (p-values)					0.9931

Notes: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses. See notes to Table 3.

PAPERS PUBLISHED IN THE 'MARKETS, INFRASTRUCTURES, PAYMENT SYSTEMS' SERIES

n. 1 TIPS - TARGET Instant Payment Settlement – The Pan-European Infrastructure for the Settlement of Instant Paymentsi, *by Massimiliano Renzetti, Serena Bernardini, Giuseppe Marino, Luca Mibelli, Laura Ricciardi and Giovanni M. Sabelli* (INSTITUTIONAL ISSUES)

n. 2 Real-Time Gross Settlement systems: breaking the wall of scalability and high availability, *by Mauro Arcese, Domenico Di Giulio and Vitangelo Lasorella* (RESEARCH PAPERS)

n. 3 Green Bonds: the Sovereign Issuers' Perspective, *by Raffaele Doronzo, Vittorio Siracusa and Stefano Antonelli* (RESEARCH PAPERS)

n. 4 T2S - TARGET2-Securities – The pan-European platform for the settlement of securities in central bank money, *by Cristina Mastropasqua, Alessandro Intonti, Michael Jennings, Clara Mandolini, Massimo Maniero, Stefano Vespucci and Diego Toma* (INSTITUTIONAL ISSUES)

n. 5 The carbon footprint of the Target Instant Payment Settlement (TIPS) system: a comparative analysis with Bitcoin and other infrastructures, *by Pietro Tiberi* (RESEARCH PAPERS)

n. 6 Proposal for a common categorisation of IT incidents, *by Autorité de Contrôle Prudentiel et de Résolution, Banca d'Italia, Commissione Nazionale per le Società e la Borsa, Deutsche Bundesbank, European Central Bank, Federal Reserve Board, Financial Conduct Authority, Ministero dell'Economia e delle Finanze, Prudential Regulation Authority, U.S. Treasury* (INSTITUTIONAL ISSUES)

n. 7 Inside the black box: tools for understanding cash circulation, *by Luca Baldo, Elisa Bonifacio, Marco Brandi, Michelina Lo Russo, Gianluca Maddaloni, Andrea Nobili, Giorgia Rocco, Gabriele Sene and Massimo Valentini* (RESEARCH PAPERS)

n. 8 The impact of the pandemic on the use of payment instruments in Italy, *by Guerino Ardizzi, Alessandro Gambini, Andrea Nobili, Emanuele Pimpini and Giorgia Rocco* (RESEARCH PAPERS) (in Italian)

n. 9 TARGET2 – The European system for large-value payments settlement, *by Paolo Bramini, Matteo Coletti, Francesco Di Stasio, Pierfrancesco Molina, Vittorio Schina and Massimo Valentini* (INSTITUTIONAL ISSUES) (in Italian)

n. 10 A digital euro: a contribution to the discussion on technical design choices, *by Emanuele Urbinati, Alessia Belsito, Daniele Cani, Angela Caporrini, Marco Capotosto, Simone Folino, Giuseppe Galano, Giancarlo Goretti, Gabriele Marcelli, Pietro Tiberi and Alessia Vita* (INSTITUTIONAL ISSUES)

n. 11 From SMP to PEPP: a further look at the risk endogeneity of the Central Bank, *by Marco Fruzzetti, Giulio Gariano, Gerardo Palazzo and Antonio Scalia* (RESEARCH PAPERS)

n. 12 TLTROs and collateral availability in Italy, *by Annino Agnes, Paola Antilici and Gianluca Mosconi* (RESEARCH PAPERS) (in Italian)

n. 13 Overview of central banks' in-house credit assessment systems in the euro area, *by* Laura *Auria, Markus Bingmer, Carlos Mateo Caicedo Graciano, Clémence Charavel, Sergio Gavilá, Alessandra Iannamorelli, Aviram Levy, Alfredo Maldonado, Florian Resch, Anna Maria Rossi and Stephan Sauer* (INSTITUTIONAL ISSUES)

n. 14 The strategic allocation and sustainability of central banks' investment, *by Davide Di Zio, Marco Fanari, Simone Letta, Tommaso Perez and Giovanni Secondin* (RESEARCH PAPERS) (in Italian)

n. 15 Climate and environmental risks: measuring the exposure of investments, *by Ivan Faiella*, *Enrico Bernardini*, *Johnny Di Giampaolo*, *Marco Fruzzetti*, *Simone Letta, Raffaele Loffredo and Davide Nasti* (RESEARCH PAPERS)

n. 16 Cross-Currency Settlement of Instant Payments in a Multi-Currency Clearing and Settlement Mechanism, *by Massimiliano Renzetti*, *Fabrizio Dinacci and Ann Börestam* (Research Papers)

n. 17 What's ahead for euro money market benchmarks?, *by Daniela Della Gatta* (Institutional Issues) (in Italian)

n. 18 Cyber resilience per la continuità di servizio del sistema finanziario, *by Boris Giannetto and Antonino Fazio* (Institutional Issues) (in Italian)

n. 19 Cross-Currency Settlement of Instant Payments in a Cross-Platform Context: a Proof of Concept, *by Massimiliano Renzetti, Andrea Dimartina, Riccardo Mancini, Giovanni Sabelli, Francesco Di Stasio, Carlo Palmers, Faisal Alhijawi, Erol Kaya, Christophe Piccarelle, Stuart Butler, Jwallant Vasani, Giancarlo Esposito, Alberto Tiberino and Manfredi Caracausi* (Research Papers)

n. 20 Flash crashes on sovereign bond markets – EU evidence, *by Antoine Bouveret, Martin Haferkorn, Gaetano Marseglia and Onofrio Panzarino* (Research Papers)

n. 21 Report on the payment attitudes of consumers in Italy: results from ECB surveys, *by Gabriele Coletti, Alberto Di Iorio, Emanuele Pimpini and Giorgia Rocco* (Institutional Issues)

n. 22 When financial innovation and sustainable finance meet: Sustainability-Linked Bonds, *by Paola Antilici, Gianluca Mosconi and Luigi Russo* (Institutional Issues) (in Italian)