BANCA D'ITALIA
EUROSISTEMA

Mercati, infrastrutture, sistemi di pagamento

(Markets, Infrastructures, Payment Systems)

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

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DIGITAL PAYMENTS AND ECONOMIC PERFORMANCE: EVIDENCE FROM ITALY

by Guerino Ardizzi*, Niccolò Lippi Boncambi*, Cristina Demma ** and Alberto Leorati*

Abstract

This paper examines the relationship between the use of digital payments and economic performance across Italian provinces from 2012 to 2023. Using a novel dataset drawn from the statistical sources of Banca d'Italia, Istat and Cerved, we construct granular indicators of digital payment usage, including card transactions, account-to-account (A2A) transfers and e-commerce activity.

By employing a dynamic panel framework that is estimated using System-GMM, we find a robust positive association between digital payment intensity and nominal GDP per capita. Provinces with greater per-capita card usage and A2A transfers exhibit a stronger economic performance, a pattern corroborated by broader measures of digital intensity, such as online-initiated payments.

While our empirical strategy addresses several endogeneity concerns, the results are not strictly causal. They suggest that greater uptake of digital payments is associated with a stronger economic performance and may reflect broader technological and economic modernization.

JEL Classification: E42; G21; G23; Q55.

Keywords: Retail payments, economic growth, network externalities, financial innovation.

Sintesi

Questo articolo esamina la relazione tra l'adozione dei pagamenti digitali e la performance economica nelle province italiane dal 2012 al 2023. Utilizzando un nuovo dataset tratto dalle fonti statistiche di Banca d'Italia, ISTAT e Cerved, costruiamo indicatori granulari di utilizzo dei pagamenti digitali, tra cui transazioni con carta, trasferimenti *account-to-account* (A2A) e attività di e-commerce.

Stimando tramite System-GMM un modello a dati panel dinamico, riscontriamo un'associazione positiva e robusta tra l'intensità dei pagamenti digitali e il PIL nominale pro capite. Le province con maggiore uso pro capite di carte e trasferimenti A2A mostrano una performance economica più elevata, un'evidenza rafforzata da misure più ampie di intensità digitale, come i pagamenti avviati online.

Benché la strategia empirica affronti la questione dell'endogeneità, i risultati non possono essere interpretati in senso strettamente causale: la correlazione tra più ampia adozione dei pagamenti digitali e migliore performance economica può riflettere più ampi processi di modernizzazione tecnologica ed economica.

* Banca d'Italia, Payments and Market Infrastructures.

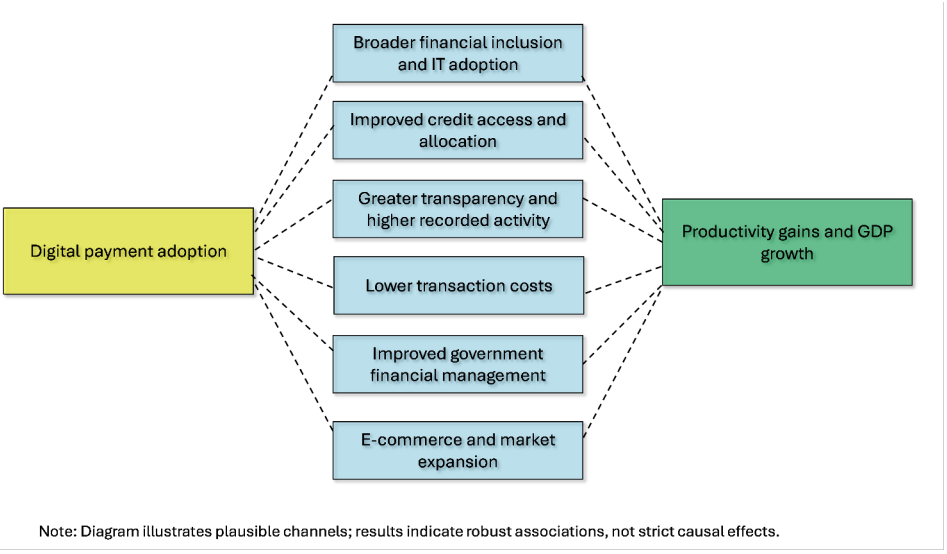
** Banca d'Italia, Palermo Branch.

Contents

1 Motivation and expected results

Over the past decade, technological innovation – particularly digital innovation – has transformed retail payments, consumers' payment habits and firms' digital adoption worldwide. Most societies around the globe are evolving towards a cashless model. This includes payment methods (e.g. credit/debit cards, contactless technologies, digital wallets), online platforms (e.g. marketplaces, ride-sharing) and emerging digital technologies (e.g. AI, blockchain). The transition, accelerated by the COVID-19 crisis and the widespread uptake of digital payments – which can be considered a proxy for digital innovation (OECD, 2019; Aguilar et al., 2024) – is widely considered a key policy lever for enhancing economic transparency, efficiency and financial inclusion, thereby fostering economic growth. Indeed, digital innovation in the payment sector – such as mobile payments, online banking, digital wallets, and contactless (NFC and QR code) payment transactions – has increased the velocity of money, changed economic dynamics and supported economic growth through several channels (Figure 1).

Figure 1
Digital payments and economic growth – Channels



First of all, digital payments, by facilitating exchange of money often through mobile devices or digital channels, promote economic growth by providing access to banking services, encouraging bank account usage, boosting economic participation and supporting broader financial inclusion (Tombini, 2023).

The views expressed are those of the authors and do not necessarily reflect those of the Bank of Italy. We are grateful to Andrea Lamorgese, Luca Jacobo Uberti and to the participants of the AIBE Conference "Digital Payments and Financial Inclusion," held at the São Paulo School of Business Administration on July 3–4, 2025, for their valuable comments and suggestions. We also thank an anonymous referee for insightful remarks that helped improve the paper.

More in detail, worldwide spending through electronic or digital payment methods in e-commerce and in-person shopping has increased nearly fivefold over the past decade, and the share of smartphones in global retail payments has increased from 5% in 2014 to 35% in 2024[1]. Digital wallet payments are being widely adopted for POS purchases, especially in developing countries where new payment methods have increased financial inclusion. Examples like Brazil's Pix[2] system and the widespread use of digital wallets in China and India show how real-time, low-cost payments can drive financial inclusion. In Europe and the U.S., where this share is around 15–20% in 2024, the trend towards digital payments via smartphone is also growing strongly on an annual basis, as is the case in Italy, where more than one in ten payments are now made via a smartphone at the POS[3].

In the near future, on a global scale, digital payments are still expected to grow by 11% in Europe and 7% in North America by 2027. Higher growth rates are expected in developing countries, such as Asia-Pacific (20%), Latin America (+16%) and the Middle East & Africa (+14%)[4]. Digital innovation is also reshaping the retail payments market with new players and services. As online spending has grown, it has largely consolidated on platforms and marketplaces such as Amazon, eBay, Alibaba, etc., which account for more than 50% of global e-commerce spending[5]. As a result, technology companies—both large (BigTech) and small (FinTech startups)—are increasingly active in payment services, or at least interested in entering this market. Another area of innovation is related to distributed ledger technology (DLT) and smart contract technologies, as well as crypto-assets developed thanks to these technologies; indeed, even though they still represent a small portion of the financial system, we have seen a dramatic increase over the last few years also in the field of commercial payments.

Furthermore, digitalization in finance is associated with an easing of credit constraints, facilitating not only broader access to finance but also a more efficient allocation of credit (Bontadini et al., 2024). Electronic payments increase transparency and reduce the usage of untraceable payment instruments (i.e. cash) which are also used in the underground and illegal economy that may further reduce fair competition and the industrial productivity (Giammatteo et al., 2022; Mastac, 2025). The widespread adoption of digital payments also lowers the overall social cost associated with economic transactions, given that cash among the most expensive payment instruments when measured against the value of payments processed (Junius, 2022). Information technologies (IT) provide additional advantages for payments to and from government agencies are significant, especially for local units. The local computer payment orders, computerized flows of data between agencies and banks, a wider range of remote services – all will also stimulate the spread of IT among households and firms

[1]Global data elaborated from the Global Payments Report 2025 (Worldpay) and Capgemini World Payments Report 2023.

[2]In Brazil, the central bank launched the fast payment system Pix in November 2020. Pix connects together over 700 banks and non-bank institutions, offering clients real-time transfers through a mobile phone interface. After its launch, the number of total bank clients increased by over 40 million in two years. It is estimated that 50 million Brazilians made their first digital payment ever, and Pix has lowered the cost of payments (Tombini, 2023).

[3]Source: Bank of Italy, banking statistics.

[4]Capgemini (2025).

[5]Statista, eCommerce: market data & analysis 2024.

(World Bank, 2020). Moreover, digital payments improve government financial management by streamlining revenue collection and transfer payments, supporting public investment and economic stability (Aguilar et al., 2024). During COVID-19, digital payments allowed the economy to reduce the negative shock on trade, allowing for remote and safe payments and making the economic system more resilient (Ardizzi et al., 2021; Demma et al., 2024). Finally, the development of digital payments facilitates international trade by lowering barriers to cross border transactions (Li et al., 2024) and supports regional trade growth and e-commerce expansion through broader market access enabled by digital finance mechanisms (Zheng, 2025). Overall, these mechanisms can lead to an increase in productivity. Indeed, Anghel et al. (2024) and Bontadini et al. (2024) find that financial digitization boosts productivity across all sectors, thereby increasing GDP. Nevertheless, empirical literature to date has paid limited attention to the impact of technological change in payment system on economic performance (Humphrey, 2006; Ardizzi et al., 2019). This is true even if it is widely recognized that a well-functioning payment infrastructure is crucial to improve efficiency both in exchange of trade and internal processes, in the procurement of new customers and lower marketing costs (European Central Bank, 2010).

Against this background, many studies find that, despite substantial national asymmetries across countries, payment innovations and products are developed and widely adopted in almost all countries. Payment innovation can take the form of prior or post payment-related value-added services (VAS), e-payments, or a combination of both. The banking sector plays an important role in promoting payment innovations, also in co-operation within and across industry sectors. Important barriers to innovation can be overcome to achieve a fully integrated, competitive, and modern retail payments market in Europe. Irrespective of the existing barriers to payment innovations, market participants are convinced that there will be a significant market for value-added services in addition to standard payment functions in the near future.

Having said that, the aim of this paper is to contribute to the debate on the relationship between innovation in payment technologies and overall economic growth in a country, using an innovative dataset that includes the most recent data about financial digitalization provided by banks and financial intermediaries at the regional level for Italy. To the best of our knowledge, the only papers on the impact of electronic payments on economic growth have been recently proposed by Birigozzi et al. (2025) and Aguilar et al. (2024), and in the past by Zandi and Singh (2010); Hasan et al. (2013); Zhang et al. (2019). However, these works are focused on cross-country analyses, where it may be difficult (or impossible) to model heterogeneity, manage problems of omitted variables and endogeneity bias due to different legal and regulatory systems, domestic currencies, fiscal policies, etc., and detect the impact of technical change—measured by the level of digitalization of payment systems—on economic performance.

By relying on the seminal papers proposed by Hasan et al. (2013) and Zhang et al. (2019), with payment data drawn from the ECB Statistical Data Warehouse to assess the impact of electronic payments on economic growth, this study intends to provide an intra-country regional analysis with a wider payment dataset in terms of digital channels—taking into consideration Italy as an

interesting 'case study' as this country is also characterized by a lower level of diffusion of e-payments with respect to other industrialized countries. Moreover, the contribution of the paper is mainly policy oriented as we consider payment innovation as a useful proxy for IT input and digitalization trends in the economy. Our paper leverages a broader dataset on digital payment adoption, offering a richer perspective than previous studies. This is an important issue given that one of the main causes of the so-called "IT paradox"[6] is the severe measurement problem of the IT input itself and such a measurement problem is more problematic for macro than for micro studies (Brynjolfsson and Yang, 1996).

However, although the literature reviewed above suggests that digital payments can be associated with economic growth through several plausible channels, these mechanisms are not tested in this paper. Our empirical strategy relies on a reduced-form dynamic panel specification and does not incorporate a structural model of transmission. Accordingly, given the challenges of identifying clear causal relationships, our expected contribution is above all to document at least a robust association between digital payment adoption and provincial economic performance. At the same time, this is, to our knowledge, the first empirical exercise for Italy that investigates the association between digital payment adoption and economic performance using granular provincial data. This unique focus provides a novel perspective compared to existing cross-country studies.

The remainder of the paper is organized as follows. Section 2 presents stylized facts highlighting significant cross-country heterogeneity in retail payment habits, with Italy notably lagging in the adoption of cashless payment methods. Section 3 describes the dataset used in the analysis, Section 4 outlines the econometric framework. Section 5 reports the main results. Section 6 discusses the limitations of the empirical strategy and robustness checks. Finally, Section 7 sets out the conclusions.

2 Geographical heterogeneity in retail payment habits

Despite the growing adoption of cashless payment methods over the past decade, substantial geographical disparities remain in Europe, with a more limited use of alternative payment methods to cash observed in Southern countries (Figure 2.a).

Among these, Italy notably lags behind: in 2023, in this country were made only 219 non-cash payments per capita, against 365 in the European Union and 395 in the euro area. In the same year, Italy ranked last among euro area countries in terms of number of per capita cashless transactions, and third to last within the European Union, ahead only of Romania and Bulgaria.

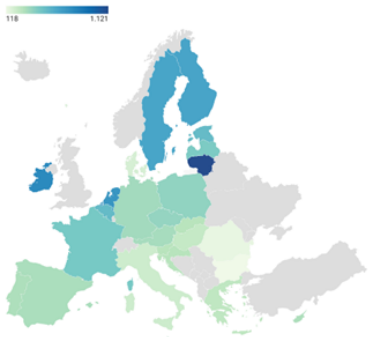
The strongest preference in Italy for cash payments does not reflect supply-side factors. According to the results of the Regional Bank Lending Survey conducted by the Bank of Italy[7], since as early

[6] In a famous interview conducted many years ago, Robert Solow remarked "You can see the computer age every-where these days, except in the productivity statistics" (New York Times, July 12th 1987). This has given rise to the "IT paradox", that is, the lack of conclusive evidence on "a productivity impact proportionate to the quantitative and qualitative importance of IT investment" (Haynes and Thompson, 2000).

[7] For methodological details about the survey, see Bank of Italy – Regional Bank Lending Survey.

Figure 2
Number of per capita cashless payments in the European Union and in Italy in 2023 (1)
(units)

(a) European Union (2)



(b) Italy

Source: European Central Bank.
(1) Number per capita of transactions made by payment cards, credit transfers, direct debits, e-money payments and cheques. In panel (a) the distinction among countries of the number of payments is based on the residence of the customers, while payment card transactions refer to the activities carried out by banks and financial intermediaries acting as issuers. Instead, in panel (b) the territorial distinction is based on the province where the transaction is executed. Payment card transactions refer to the activities carried out by banks and financial intermediaries acting as acquirers. – (2) The map does not include Luxembourg due to the exceptionally high number of per capita transactions, which reflects the large volume of e-money payments, including peer-to-peer transactions.

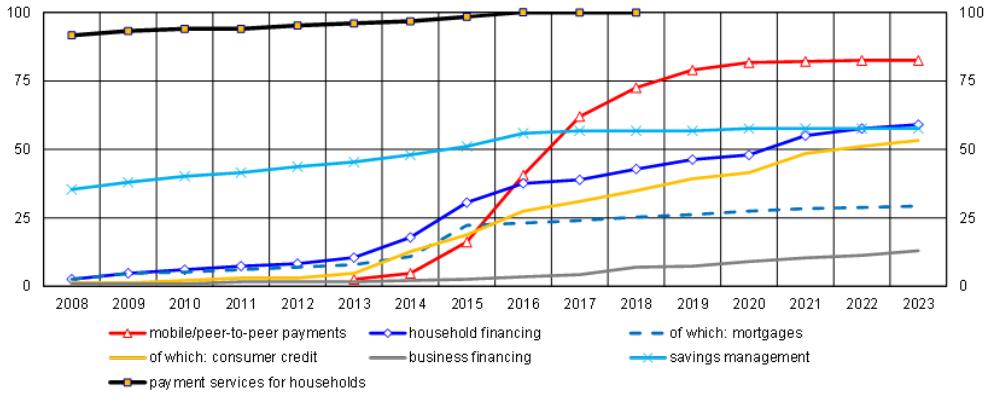
as 2016 all surveyed banks had been offering digital payment services to households. In 2023, a high share – over 80 percent – of banks offered their customers the ability to make mobile micropayments (Figure 3). As a result, Italians have broad access to alternatives to cash.

Conversely, in Italy there is a stronger preference for cash for transactional purposes in consumers' behavior (Di Iorio and Rocco, 2022; European Central Bank, 2024). According to the ECB's 2024 SPACE[8] survey, 20 percent of Italian consumers prefer paying with cash, while 61 percent favor card or digital payments. Despite the majority favoring digital methods, cash remains the most frequently used payment instrument in shops, accounting for 61 percent of total payments, compared to 32 for cards and 4 for mobile apps (52, 39 and 6 percent in the euro area, respectively).

Hence, the high reliance on cash in Italy appears to be primarily driven by demand-side factors. The Bank of Italy's Survey on Household Income and Wealth[9] provides insights into the relationship between cash usage and households' socio-economic characteristics. In 2022, 25 percent of Italian households' consumption expenditure was made in cash, down from 30 percent in the previous survey wave and 40 percent two editions earlier. This share was significantly higher among households with low income, and among those where the head of household has a low level of education, is older,

[8]Study on the payment attitudes of consumers in the euro area (SPACE). For more information about the survey, see European Central Bank – SPACE Survey.
[9]For more information, see Bank of Italy – Survey on Household Income and Wealth (SHIW).

Figure 3
Provision of banking services through digital channels (1)
(annual data; percentage shares)



Source: Bank of Italy – Regional Bank Lending Survey.
(1) Share of banks responding affirmatively to the questions regarding the provision of digital products, as listed in the legend, included in the section of the survey on the supply of digital services. For banking groups other than cooperative ones, only one consolidated response is considered. "Mobile/peer-to-peer micropayments" refer to technologies that allow users to make low-value payments or transfer money using specific software, accessible via dedicated applications on smartphones and other devices. Financing services for households and businesses refer to the provision of tools that enable users to request quotes, apply for credit, or take out loans via the internet. For overall household financing, banks are considered to offer the service through digital channels if they provide at least one product among mortgages or consumer credit.

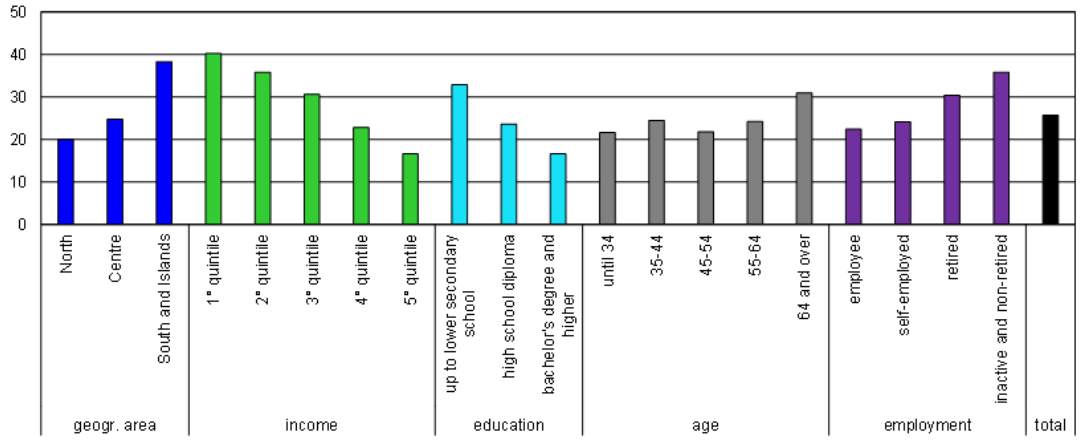
retired, or unemployed. Moreover, households in Southern Italy tend to use cash for a larger share of their consumption expenditure (40 percent; Figure 4).

The gap in the use of cashless payments was therefore even more pronounced in Southern Italy (Figure 2.b). On average, in 2023, the per capita number of such payments in this geographical area was approximately 130, 100 fewer than in the Centre-North[10]. This disparity is primarily due to the more limited use of payment cards in the South. However, even in Lazio, the region with the highest number of per capita non-cash transactions, this figure was lower compared to the euro area average. Consequently, to the extent that the spread of innovative payment technologies has a positive impact on the economic performance of a region, part of the gap between regions in terms of GDP per capita, which is unfavorable to the South, may be attributed to the lower use of these tools in this area[11].

[10]The data for the Centre-North and the South are not comparable with the national average, which is 219, because they are based on reports of payment card transactions carried out by banks and financial intermediaries acting as acquirers, rather than issuers.

[11]In 2023, per capita GDP in South and Islands was substantially lower than in Central and Northern Italy, amounting to approximately 57% of the latter.

Figure 4
Share of consumption expenditure in cash in 2022
(percentage shares)



Source: Bank of Italy – Survey on Household Income and Wealth.

3 Data

Data on payment statistics are taken from the Bank of Italy and cover the period 2012–2023. They are disaggregated at the provincial level and do not take into account the small changes in administrative boundaries that may have occurred during this time period. The data comprehend information about: (i) number of cash withdrawals from ATM or at the bank branch, (ii) value of payments through POS with debit, credit, and pre-paid cards, (iii) value of electronic payments, (iv) number of ATMs, (v) number of POS and (vi) number of e-banking users. Since 2022, are also available data at provincial level about: (vii) number of payment cards, divided into virtual and non-virtual, (viii) e-commerce transactions, including online sales by Italian firms adopting digital channels, (ix) value of credit transfers and direct debits (so-called A2A payment models[12]) made via mobile with P2P, B2B or C2B methods and (x) value of card payments by product sector.

Yearly data on GDP and inflation at the provincial level have been retrieved from ISTAT[13]. From the Cerved database, that reports granular data on the main financial statement indicators of Italian non-limited companies, we calculate a proxy of factor intensity at provincial level, defined as the labor cost per capita. The dataset also includes socio-demographic variables (drawn from the ISTAT database) such as the age composition of the population of each province.

[12]The Account-to-Account (A2A) payment model refers to the direct transfer of funds (including fast and instant payments) between two bank accounts, without the need for intermediaries like card networks (e.g., Visa or Mastercard). In Italy such kind of payment model are still mainly used for P2P and B2B transactions.

[13]ISTAT's provincial GDP includes adjustments for the non observed economy (NOE). Within our policy-oriented objective, official GDP remains the relevant outcome.

4 Methodology

Building on the previous literature in the field of digital payments contributions to economic growth (Hasan et al., 2013) we test a set of hypotheses about the relationship between efficient non-cash payments diffusion and economic performances. To this aim, we estimate a dynamic panel equation. The baseline model is the following:

$$y_{it} = \alpha\, y_{i,t-1} + X_{it}\,\beta + \mu_i + \varepsilon_{it} \tag{1}$$

where y is the nominal GDP per capita for each province i and year t, X collects the covariates for both payment instrument penetration variables and socio-economic controls, μ_i denotes province fixed-effects and ε_{it} is an error term with $\mathbb{E}(\varepsilon_{it}) = 0$ for all i and t. All variables are in logs and in per capita terms.

However, estimating equation (1) with ordinary least squares or fixed-effects would be inappropriate for four main reasons. First, dynamic bias: the presence of fixed-effects makes the OLS inconsistent (i.e., positive correlation between the lagged dependent variable and the error term) and the within-estimator is biased downwards (i.e., Nickell bias, Nickell, 1981). Second, endogeneity: the digital-payment adoption can itself be driven by local economic conditions, and both variables may respond simultaneously to unobserved provincial shocks, causing reverse causality and omitted-variable bias. Third, measurement error and persistence. Fourth, large N (102) and small T (11).

To address these issues our empirical strategy relies on the dynamic panel Generalized Method of Moments (GMM) estimator (Arellano and Bond, 1991; Blundell and Bond, 1998). However, it has been shown (Alonso-Borrego and Arellano, 1999) that the difference-GMM estimator exhibits finite-sample bias in panels with few time periods and highly persistent dependent variables, and, additionally, it rules out the cross-province effect by taking the first difference.

As a result, we employ a System-GMM estimator, which is well-suited to these contexts. In particular, a system of two equations is built, in levels and first difference, and we use as internal instruments lags of both dependent and independent variables such that the following moment conditions hold:

$$\mathbb{E}\left[z_{i,t-s}\,\Delta\varepsilon_{it}\right] = 0, \quad s \geq 2 \tag{2}$$

$$\mathbb{E}\left[\Delta z_{i,t-s}\,(\varepsilon_{it} + \mu_i)\right] = 0, \quad s \geq 2 \tag{3}$$

where $z_{i,t}$ collects endogenous regressors. The two orthogonality conditions ensure that (i) the lagged values of endogenous variables in levels constitute a valid set of instruments for the differenced equation, and (ii) their first differences can be used as additional instruments in the level equation.

Furthermore, in order to enhance finite-sample performance, instrument reduction through collapse and finite-sample correction standard errors (Windmeijer, 2005) are employed. Following the estimation, we report the Hansen test for over-identifying restrictions as well as the Arellano–

Bond AR(1) and AR(2) tests. Together they confirm the validity of the whole set of instruments. Moreover, to assess the robustness of our analysis, we expand it by estimating pooled OLS, within fixed-effects OLS, and difference-GMM specifications and compare their results to those obtained from our System-GMM estimator.

5 Econometric results

5.1 Baseline Volume Specification

In this Section, we present the main findings from our dynamic panel estimations. Our dependent variable is the nominal GDP per capita and its lagged value is used to account for persistency in economic performance. To investigate the link between system of payments and economic growth, we include the following regressors: (i) cash withdrawals (i.e., proxy of demand for cash), (ii) checks, (iii) payment cards transactions, (iv) direct debits, (v) credit transfers. All the variables in our model are measured as per-capita volume of transactions done through the respective payment channel (monetary variables are considered in nominal value). In particular, in our main specification, we jointly include online credit transfers and direct debits as a single regressor to capture the account-to-account (A2A) payment models, which also reflect the degree of digitalization in the payments system. To control for confounding factors, we add socio-demographic and economic controls: labor cost per capita, as a proxy for provincial wage levels and factor intensity; the old-age dependency ratio[14], to account for demographic differences; year-on-year provincial inflation to control for price-level changes since both our dependent variable and regressors are measured in nominal terms. In addition, we include two-time dummies (2020 and 2021) to account for the pandemic shock.

Table 1 illustrates estimates from four model specifications: Pooled OLS, Fixed Effects, Difference-GMM, and the one of interest System-GMM. Looking at the coefficient on the lagged GDP per capita term, we see the familiar feature of dynamic panel estimators. In our results, pooled OLS presents the highest persistence (0.966), while fixed-effects gives the lowest (0.722). According to the literature (Nickell, 1981; Arellano and Bond, 1991; Blundell and Bond, 1998; Roodman, 2009), a properly specified GMM estimator should lie between these two coefficients, and indeed, our system-GMM estimate of 0.939 lies in that confidence interval. One reason the difference-GMM estimate (0.670) lies slightly below the fixed-effects bound regards the weak instruments issue in the differenced equation when series are too persistent, as in our case. Accordingly, we focus on the system-GMM estimates reported in the fourth column.

Our findings suggest that, once both dynamic bias and endogeneity are properly addressed, all the more "traditional" channels, cash withdrawals and traditional bank transfers (covering telematic, ATM and at-the-counter bank transfers), lose statistical significance in the system-GMM model, explaining essentially none of GDP. Only checks present a small negative effect, and even that is only marginally significant at the 10% level. By contrast, both payment cards (more focused on B2C

[14]The ratio of the population aged 65+ to the working-age population.

transactions) and A2A digital transfers (including P2P and B2B operations) deliver robust, positive associations on local economic performance. Thus, a 10% increase in per-capita card transactions is associated with a 0.33% rise in nominal GDP, while a 10% increase in account-to-account transfers per capita is related with a 0.42% rise in GDP. Our findings indicate that digital payment indicators are strongly correlated with provincial GDP[15] under a dynamic panel framework, while traditional channels (cash withdrawals, bank transfers, and checks) fail to show explanatory power. These associations remain robust after controlling for endogeneity and dynamic bias.

The row for the Hansen p-values looks at the validity of the over-identifying restrictions. In all specifications we do not reject the null hypothesis[16]. The values reported for AR(1) and AR(2) are the p-values for first- and second-order autocorrelated disturbances in the first-difference equation. As expected, there is high first-order autocorrelation, and no evidence for significant second-order autocorrelation. These hypothesis tests imply that we have a valid set of instruments.

Our empirical findings are broadly aligned with the international literature on the economic effects of digital payments, and estimated coefficients are consistent with those reported by Hasan et al. (2013), Zandi and Singh (2010), Aguilar et al. (2024), and Birigozzi et al. (2025), reinforcing the view that digital payment adoption is a key driver of economic performance.

Table 1: Baseline Specification

	(1) Pooled OLS	(2) Fixed Effects	(3) Diff–GMM	(4) Sys–GMM
GDP_{t-1}	0.966^{***}	0.722^{***}	0.670^{***}	0.939^{***}
Checks	-0.012^{***}	-0.041^{***}	-0.035^{*}	-0.015
Cash proxy	0.030^{***}	-0.031^{***}	-0.074^{***}	0.014
Traditional bank transfers	-0.002	0.002	0.045^{***}	0.001
Payment cards	0.008^{*}	0.021^{***}	0.011^{*}	0.033^{**}
A2A-digital transfers	0.018^{***}	0.011^{*}	0.032^{***}	0.042^{***}
Controls	Yes	Yes	Yes	Yes
Observations	1,122	1,122	1,122	2,172
Provinces	102	102	102	102
Hansen p-value	—	—	0.331	0.213
AR(1) p-value	—	—	0.001	0.001
AR(2) p-value	—	—	0.545	0.698

Notes: Pooled and Fixed Effect regressions use robust standard errors clustered by provinces. All GMM regressions use robust standard errors and treat GDP as endogenous. All payment-system regressors (cash withdrawals, checks, traditional bank transfers, payment cards, and A2A digital) are treated as endogenous. Lagged variables are used as instruments to solve simultaneity and reverse causality issues. For two-step GMM, the Windmeijer (2005) finite-sample correction is applied. Controls: labor cost per capita, inflation, and old-age dependency ratio. Hansen test reports p-values for instrument validity. Collapse option used to limit proliferation of instruments. The number of instruments used in the System-GMM specification is 85 and remains below the number of provinces (N = 102). Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

[15]Similar findings can be obtained by considering value added per worker (VA) as alternative economic performance indicator.

[16]Roodman (2009) recommends, as a rule of thumb, that the Hansen p-value should fall between 0.10 and 0.25 (or, at most slightly higher) to avoid instrument proliferation.

5.2 Digital-Intensity Specification

To better verify that the growth effects detected in Section 5.1 is correlated with the diffusion of digital instruments rather than transaction volumes, we re-estimate the dynamic panel with a different specification. Now, the payment variables are reshaped so that each channel enters the regression twice: once in levels and once as a measure of its digital penetration. The key regressor total A2A transfers is defined as the total per-capita amount of account-to-account transfers (i.e., the sum of all credit transfers and direct debits, including instant or fast payments). Its companion variable digital-intensity ratio is a compositional indicator equal to the ratio of digitally initiated transfers to total A2A transfers; thus, a positive coefficient on digital-intensity ratio, conditional on total A2A transfers, signals that shifting the mix toward online execution, holding the overall volume fixed, is associated with an increase in provincial GDP.

The same logic is applied to payment cards. They record the aggregate number of transactions made with credit, debit, and prepaid cards, irrespective of whether the payment took place in a physical point of sale or in an e-commerce environment. Because a transaction-level split between "traditional" and "digital" card usage is not available in our dataset, we proxy the intensity of card-based digitalization with Online Purchase Ratio, the percentage of residents who carried out at least one online purchase during the year. A significant coefficient on this variable, conditional on Payment Cards, indicates that the same card volume is correlated with a greater local value added in provinces where on-line purchasing is more widespread. The socio-economic controls are the same as the previous section.

Table 2 shows the outputs from the Digital-Intensity Specification. Column (4), our baseline system-GMM, shows that once we control for total payment volumes, higher digital-intensity ratios still deliver extra GDP gains. The share of account-to-account transfers initiated online adds to growth over and above the effect of the transfer volume, and the share of residents making at least one online purchase boosts local value added beyond total card transactions. Together, these compositional terms suggest that the growth impact of established infrastructures is stronger when a larger share of existing payment flows occurs through digital channels.. The standard Hansen and AR tests indicate that our instruments are valid.

6 Limitations and Robustness

As previously mentioned, the System-GMM estimator offers an effective strategy for addressing potential endogeneity issues in dynamic panel settings, particularly when the number of cross-sectional units is large and the time dimension is relatively short. In our framework, the relationship between digital payment methods and economic performance is likely bi-directional, with each influencing the other. To mitigate this issue, we employ lags of the regressor variables as internal instruments, following the methodology proposed by Arellano and Bond (1991) and Blundell and Bond (1998). These lagged values are assumed to be valid instruments—correlated with the endogenous regressors but uncorrelated with the contemporaneous error term. Under this

Table 2: Digital–Intensity Specification

	(1) Pooled OLS	(2) Fixed Effects	(3) Diff–GMM	(4) Sys–GMM
GDP_{t-1}	0.962^{***}	0.724^{***}	0.692^{***}	0.923^{***}
Checks	-0.006	-0.028^{***}	-0.034	0.014
Cash withdrawals	0.028^{***}	-0.039^{***}	-0.073^{***}	-0.014
Total A2A transfers	0.011^{***}	0.016^{*}	0.087^{***}	0.058^{***}
Digital–Intensity Ratio	0.064^{***}	0.037	0.038	0.112^{***}
Payment cards	0.002	0.015^{*}	0.001	0.001
Online Purchases Ratio	0.096^{***}	0.132^{***}	0.190^{**}	0.268^{***}
Controls	Yes	Yes	Yes	Yes
Observations	1,122	1,122	1,122	2,172
Provinces	102	102	102	102
Hansen p-value	—	—	0.136	0.207
AR(1) p-value	—	—	0.001	0.001
AR(2) p-value	—	—	0.614	0.671

Notes: Pooled and Fixed Effect regressions use robust standard errors clustered by provinces. All GMM regressions use robust standard errors and treat GDP as endogenous. All payment-system regressors (cash withdrawals, checks, traditional bank transfers, payment cards, and A2A digital) are treated as endogenous. Lagged variables are used as instruments to solve simultaneity and reverse causality issues. For two-step GMM, the Windmeijer (2005) finite-sample correction is applied. Controls: labor cost per capita, inflation, and old-age dependency ratio. Hansen test reports p-values for instrument validity. Collapse option used to limit proliferation of instruments. The number of instruments used in the System-GMM specification is 88 and remains below the number of provinces (N = 102). Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

assumption, consistent parameter estimation is possible through the moment conditions exploited by System-GMM.

However, we acknowledge that this remains a somewhat mechanical approach to identification and does not provide a fully causal interpretation of the estimated effects. While System-GMM corrects for endogeneity, it does not inherently offer a natural experiment. If the lags used as instruments are not truly exogenous, then the identification is internal and may not yield causal inference. Therefore, caution is warranted when interpreting the results. A more robust identification strategy would ideally involve exogenous variation, such as a policy reform independent of provincial economic conditions, or an external instrumental variable that satisfies both relevance and exogeneity. These approaches offer clearer causal interpretations but are difficult to implement due to data limitations and the challenge of identifying valid external instruments.

Although the literature has employed external instruments such as broadband penetration and the density of mobile money agents (Aguilar et al., 2024)[17], none of these is feasible in our Italian provincial context. Nonetheless, to further test the robustness of our findings, we augmented the dynamic panel estimates with instrumental variable regressions, using the provincial diffusion of broadband technologies as exogenous sources of variation in digitalization. Specifically, we used two proxies: the share of the provincial population covered by fiber-to-the-home (FTTH) networks and

[17]The authors recognize the concern of weak instruments even in their setting, mainly regarding the exogeneity assumption.

the share covered by Very-high-bit-rate Digital Subscriber Line 2 (VDSL2) vectoring technology. Provinces with higher FTTH coverage exhibit greater access to high-speed and reliable broadband connectivity, thereby facilitating digital payment usage, e-commerce, and business digitalization. FTTH coverage can be interpreted as a plausibly exogenous proxy, since broadband infrastructure investments are typically driven by national or regional deployment plans and operators' technical considerations rather than short-term provincial economic conditions. A similar rationale applies to VDSL2 coverage, which also serves as a proxy for local digital payment diffusion.

Results from the IV model (not reported for the sake of brevity[18]) confirm a positive and statistically significant association between digitalization and economic performance when using FTTH as an instrument for A2A digital transfers, consistent in sign and magnitude with those obtained from the System-GMM specification. However, the first-stage regression indicates weak instrument relevance, as FTTH coverage shows only modest correlation with the endogenous regressor, suggesting that these results should be interpreted with caution. By contrast, when using VDSL2 coverage as a proxy, the estimates lose statistical significance and exhibit the same weak-instrument issue observed with FTTH. Moreover, the narrow sample period[19] constrains time-series variation and limits the model's ability to capture the dynamic link between digitalization and economic performance.

In conclusion, our analysis should be interpreted as providing robust empirical associations between digital payments and economic performance, under a carefully specified dynamic framework, rather than definitive causal claims. Future research may seek to combine our innovative dataset with alternative identification strategies aimed at causal interpretation.

7 Conclusions

This study provides robust empirical evidence of a significant correlation between digital payment adoption and economic performance in a country. Digital payment adoption may influence economic performance through channels such as lower transaction costs, greater transparency, and complementarity with broader digitalization processes (e-commerce and IT adoption by firms). However, our empirical strategy does not identify these mechanisms within a structural model; rather, it follows a reduced-form approach, in line with existing literature on this topic. Compared to the traditional literature on the impact of retail payment instruments on GDP, which typically relies on cross-country analyses based on a limited set of payment indicators, this study benefits from a richer and more detailed dataset on retail payment instruments and digital channels, within a single jurisdiction (i.e. Italy). Although this approach allows us to mitigate common issues such as omitted variable bias and endogeneity that often affect cross-country studies, results should be interpreted with caution, as they do not imply strict causal relationships. Moreover, to our knowledge, this is the first provincial level analysis for Italy on this relationship, providing context specific insights that complement existing cross country evidence.

[18] Estimates are available from the authors upon request.

[19] VDSL2 coverage data are available only for 2020–2023.

Using a dynamic panel model with System-GMM estimation on Italian provincial-level data from 2012 to 2023, we find that digital payment instruments—particularly card transactions and account-to-account (A2A) digital transfers—are positively and significantly associated with nominal GDP growth. Specifically, a 10% increase in per-capita card transactions (especially P2B payments) is associated with a 0.33% rise in GDP, while a 10% increase in A2A digital transfers (mainly B2B payments) corresponds to a 0.42% increase in GDP. These correlations remain robust even after controlling for endogeneity, dynamic bias, and socio-demographic factors such as labor costs, inflation, and population ageing. Furthermore, our digital-intensity specification for retail payments reveals that not only the volume but also the mode of payment matters: a higher share of online-initiated transfers and greater e-commerce participation are associated with additional GDP gains. Importantly, these associations appear to be stronger in provinces with higher levels of digitalization, suggesting that disparities in payment habits may contribute to persistent regional gaps in economic performance.

Finally, while these correlations are consistent with international literature, they do not establish a causal link. However, building on these results, future research could explore several promising directions. First, incorporating spatial econometric models would allow capturing inter-regional spillover effects and better understanding how digital payment diffusion interacts with existing regional disparities in economic performance. Second, disaggregating the analysis by economic sectors could clarify which industries benefit most from digital payment adoption, particularly examining links with e-commerce growth and productivity improvements. Lastly, extending the temporal scope beyond 2024 to cover a longer post-pandemic period would enable a better understanding of the long-term structural changes in payment habits and their lasting effects on economic performance, especially in light of shifting consumer behaviors, accelerated digitalization, and evolving regulatory frameworks.

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