The Real Effects of Going Cashless: Evidence from China's Provinces[1]

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First draft: August, 2025
This draft: Jan., 2026

Abstract: We investigate the real effects of cashless payment expansion using a quarterly panel of 31 Chinese provinces from 2017 to 2023. Leveraging clearinghouse data, we find that a 10 percentage point increase in cashless payment growth corresponds to a 0.86 percentage point rise in GDP growth. Gains are concentrated in the secondary and tertiary sectors, driven primarily by card-based transactions. Conversely, note-based payments are relevant only for the primary sector, suggesting a link between payment modernization and industrial upgrading. Mechanism tests identify a payment-efficiency channel and a financial-inclusion channel. Heterogeneity analysis suggests the effect is larger in regions where traditional finance is weak. Instrumental-variable estimates support a causal interpretation and reveal that OLS results are downward biased. Beyond GDP, cashless expansion reduces income inequality and enhances fiscal capacity, firm entry, and fixed-asset investment.

Keywords: cashless payment; economic growth; sectoral heterogeneity; financial inclusion; income inequality

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1. Introduction

With digital wallet transactions reaching $13.9 trillion in 2023, non-cash payments[1] have moved from a technological alternative to a primary driver of global commerce. Currently accounting for half of all e-commerce activity, these systems are projected to surpass $25 trillion in volume by 2027 (Worldpay, 2024). The rise of interoperable rails like India's UPI and Brazil's Pix underscores a systemic shift toward cashless economies. In China, retail payments have rapidly moved from cash to cards, QR codes, and mobile platforms, supported by regulatory reform and FinTech innovation (Ouyang, 2023; Tan et al., 2025). Despite this rapid adoption, the relationship between digital payment penetration and regional economic performance remains an area of critical inquiry. Prior work links cashless adoption to inclusion and macro activity (Zhang et al., 2019). Building on this literature, we use clearinghouse-level transactions and a quarterly panel of 31 provinces from 2017 to 2023 to quantify how variation in non-cash payment growth maps into regional GDP, with attention to efficiency and inclusion mechanisms.

The relationship between payment systems and macroeconomic performance has gained renewed attention amid the global expansion of cashless payments (Higgins, 2024; Ong & Chong, 2023; Wisniewski et al., 2024). Classical monetary theory treats payment instruments as neutral under frictionless conditions (Lucas & Stokey, 1987). However, in the presence of transaction costs, liquidity constraints, and information asymmetries, payment choices can influence real outcomes. Building on these frictions, New Monetarist models emphasize how payment mechanisms affect transaction efficiency and money velocity (Williamson & Wright, 2010), while financial development theories highlight their role in fostering growth through improved credit access (Levine, 2005). In underbanked regions, cashless systems can substitute for formal financial services, promoting financial inclusion and inclusive growth (Demirguc-Kunt et al., 2018; Suri & Jack, 2016). Particularly in urban and underserved areas, they reduce transaction costs, expand access to credit, and support small business

[1] Cashless payments are defined as any transaction not settled with physical cash. And we distinguish cashless payments from digital payments which are executed via electronic channels.

activity. Despite growing attention to FinTech and financial inclusion, limited research has directly examined how specific payment instruments affect regional GDP and sectoral growth. The broader macroeconomic consequences of cashless payments remain insufficiently understood.

China offers an ideal setting to examine the effects of cashless payments on economic growth. First, cashless systems are deeply integrated into the country's financial infrastructure, facilitating consumer spending, business transactions, and interbank settlements. Aforesaid are the key drivers of regional economic activity. The People's Bank of China and commercial banks have actively promoted adoption, making cashless usage a meaningful proxy for financial modernization and transaction efficiency (Wong et al., 2020b). Second, China's 31 provinces vary widely in economic size, financial depth, and digital infrastructure, providing rich regional and temporal variation for empirical analysis. Their institutional autonomy and scale resemble subnational units in other large economies, making them suitable for studying macro-level effects. Third, we utilize quarterly data on real GDP growth and disaggregated non-cash payment instruments from 2017 to 2023, allowing for fine-grained analysis of both economic outcomes and payment dynamics—an advantage over annual or household-level studies. Fourth, while prior research focuses on access or adoption of a certain technology, few studies link cashless payments to macroeconomic performance. By leveraging sectoral GDP data and relatively higher-frequency payment indicators, we directly assess how digital finance translates into growth.

This study quantifies the contribution of specific cashless payment instruments to regional economic growth and identifies the underlying channels of influence. Utilizing a province–quarter panel from 2017Q1 to 2023Q1 constructed from clearinghouse-level records that comprehensively cover China's banking payment system, we disaggregate the effects of specific non-cash instruments, including paper notes, cards, and other electronic methods, on GDP growth across sectors and institutional settings. Our baseline results indicate that cashless payments materially raise growth; specifically, each 10 percentage point rise in cashless payment growth corresponds to

approximately 0.86 percentage points of higher GDP growth. These gains are concentrated in the tertiary sector and, to a lesser extent, the secondary sector. While card-based transactions emerge as the primary catalyst for growth in modern sectors, note-based payments exhibit a negative average growth rate of -12.33% and contribute significantly only to the primary sector. Indeed, note-based instruments show a negligible or even negative correlation with overall GDP, a finding consistent with the premise that advanced cashless payment technologies are structurally linked to industrial upgrading.

Decompositions of these effects reveal that both transaction frequency and average ticket size are significant, though the growth impact is primarily driven by the "price channel" of higher-value card transactions rather than mere transaction counts. Furthermore, the growth-enhancing effects are significantly amplified in provinces with lower financial marketization, fewer bank branches, and higher rural or uneducated populations. This evidence supports a "leapfrogging" financial inclusion channel where digital rails substitute for sparse traditional banking infrastructure. Critically, our instrument with social trust and geographic friction to reveal that OLS estimates are downward biased, suggesting a significantly larger causal impact than simple correlations imply. Beyond GDP, we find that the expansion of cashless payments reduces income inequality and fosters broader economic resilience through increased tax revenues and firm entry.

This paper contributes to the literature on digital finance, payment systems, and economic growth in three main ways: First, we isolate the macroeconomic effects of specific cashless payment instruments on regional economic growth. We empirically disentangle the economic effects of specific payment instruments, showing that card-based payments consistently drive real GDP growth, supporting the view that payment system modernization reduces transaction costs and enhances economic efficiency. While prior research has documented the broader relationship between digital financial services and growth(e.g., Beck et al., 2022), few studies disaggregate the impact of payment instruments themselves. By distinguishing between different transaction

modes, we complement and extend the work of Zins & Weill (2016), demonstrating that card-based payments are the primary drivers of GDP growth. Our findings offer empirical support to New Monetarist theory (Williamson & Wright, 2010), which emphasizes the role of payment efficiency in reducing market frictions and enabling higher output.

Second, we uncover sector-specific heterogeneity in the growth effects of cashless payments, showing that card transactions disproportionately benefit the secondary and tertiary sectors, while note-based payments exhibit modest but significant effects in the primary sector. This contributes to a nascent body of work examining how financial innovation interacts with industrial structure (e.g., Beck & Demirguc-Kunt, 2006; Greenwood & Jovanovic, 1990). It highlights that formal, digitally traceable payment tool are better suited to urbanized and service-oriented economies, while cash-like instruments remain relevant for rural and informal sectors, underscoring the importance of tailoring financial infrastructure to sectoral and regional needs in promoting inclusive growth.

Third, we assess how temporal and institutional contexts shape the growth of returns to cashless payment adoption. Our heterogeneity tests provide empirical validation of the leapfrogging hypothesis in digital finance (Kpodar & Andrianaivo, 2011; Suri & Jack, 2016): returns are substantially larger where traditional financial infrastructure is weakest, as modern payment rails substitute for missing banking services and deliver outsized growth dividends in financially underdeveloped areas. Mechanism analysis indicates that the expansion of cashless payments is associated with reduced income inequality, which in turn fosters more inclusive and durable economic growth. Additional evidence shows that cashless payment growth is positively linked to fiscal revenue, firm creation, and fixed asset investment, reinforcing its broader role in regional economic development and resilience during systemic disruptions.

The remainder of the paper is organized as follows: Section 2 reviews prior literature on digital payments and growth, and outlines hypotheses, leveraging theories of transaction cost economics and financial inclusion. Section 3 describes data sources

and the variables of interest. Section 4 presents empirical results, including instrumental variable analyses to address endogeneity issues. Section 5 concludes with policy recommendations and future research directions.

2. Literature review and hypothesis development

Prior literature identifies a wide range of factors driving economic growth, including macroeconomic policies (Posch & Wälde, 2011; Schularick & Solomou, 2011), human capital (Cinnirella & Streb, 2017; Kalaitzidakis et al., 2001), financial development (Benhabib & Spiegel, 2000), and institutional quality (Dincecco & Katz, 2016; Dincecco & Prado, 2012; Glaeser et al., 2004; Dawson & Seater, 2013; Yao & Zhang, 2015). Complementary forces of growth include foreign aid (Galiani et al., 2017), urbanization (Henderson, 2003), and socioeconomic equality, including both income distribution (Halter et al., 2014; Voitchovsky, 2005) and gender-equitable investment (Doepke & Tertilt, 2019; Lagerlo, 2003) , all of which shape regional growth outcomes. More recent work highlights geographic and behavioral influences. Historical remoteness (Özak, 2018) and local natural resources (Cavalcanti et al., 2019) affect regional growth trajectories, while targeted credit to emerging sectors supports structural transformation (Silva et al., 2021). Cultural and linguistic traits influence growth-related behavior. For instance, weak future-time-reference languages correlate with higher entrepreneurial activity(Campo et al., 2024), and intergenerational mobility enhances regional development (Neidhöfer et al., 2024).

The adoption of digital payments brings financial inclusion to society by transforming how transactions are conducted, lowering transaction costs, and improving credit access. Ouyang (2022) uses data from China's Alipay, shows that mobile payment platforms expand credit availability among financially excluded groups by acting as proxies for creditworthiness. Similarly, Zhang et al. (2019) and Tee & Ong (2016) find a positive association between electronic payments and GDP across European economies, primarily driven by improved transaction efficiency and greater financial inclusion. Complementary to this, Singh Dubey et al. (2023) show that India's

UPI system boosts household income and small business activity in financially underserved regions.

Theoretically, cashless payment systems reduce transaction costs and improve allocative efficiency, thereby increasing economic output (Levine, 1999; Williamson & Wright, 2010). By lowering frictions in exchange and enabling faster, more secure transactions, these systems facilitate market participation and resource mobility. In parallel, digital payments help bridge information asymmetries in credit markets, expanding access to finance and reducing constraints to consumption and investment.

Empirical research supports these mechanisms. Electronic and mobile payments are positively associated with GDP growth, especially through channels of financial inclusion and transaction efficiency(Wong et al., 2020a; Zhang et al., 2019). These effects are amplified in underbanked areas, where digital finance substitutes for traditional banking infrastructure(Beck & Demirguc-Kunt, 2006; Jack & Suri, 2014; Ouyang, 2023). Broadband access, as a foundational component of digital infrastructure, has also been shown to promote economic growth (Czernich et al., 2011).

Recent micro-level studies provide further evidence of these dynamics in action. Beck et al. (2022) show that QR-based mobile payments allow small and offline merchants to access big tech credit via data-driven scoring, and generate spillover benefits by facilitating integration into formal banking channels, particularly during the COVID-19 shock. Similarly, Dubey & Purnanandam (2023) find that the rollout of India's Unified Payments Interface (UPI) significantly increased household income and small business activity in financially underserved regions by easing borrowing constraints and reducing transaction costs.

Taken together, these findings suggest that digital payments can catalyze regional economic growth by enhancing efficiency, expanding credit access, and accelerating financial integration. These effects are particularly salient in less developed regions with limited financial infrastructure, aligning with Clemens & McKenzie (2018) emphasis on the need for disaggregated analysis to uncover heterogeneity in financial flows' macroeconomic effects. Ben Zeev (2021) further supports the view that credit

expansion driven by financial innovation impacts growth more through demand-side channels than through productivity. It is worth noting, however, that the trajectory of these benefits may involve short-term institutional frictions. Tang et al. (2022) show that in the initial three years following adoption, digital payments may inadvertently facilitate corruption due to regulatory gaps, a phenomenon that eventually subsides over time.

Based on this literature, we propose the following hypothesis:

H1: Cashless payment penetration is positively associated with regional economic growth.

Among various cashless payment methods, card-based transactions stand out for their formality, traceability, and compatibility with credit evaluation systems and data analytics (Ouyang, 2023). These features make them particularly effective in stimulating economic activity through enhanced consumption and investment flows. Consistently, Wong et al. (2020b) find that debit card usage significantly promotes GDP growth in OECD countries, whereas other instruments have limited impact. While most studies do not distinguish between payment instruments, Zhang et al. (2019) show that greater penetration of electronic methods is positively associated with GDP, trade, and consumption, with effects moderated by macroeconomic shocks and the size of the shadow economy. Compared to more fragmented or informal payment types, card transactions provide more reliable data trails and better integration with formal credit systems, thereby amplifying their growth potential. Therefore, we propose the following hypothesis:

H2: Card-based transactions exhibit a stronger positive effect on GDP growth than note-based or alternative payment methods.

Credit supply shocks may have limited effects on productivity via capital misallocation but can drive growth through liquidity channels (Ben Zeev, 2021). Sectors with high transaction frequency and consumer exposure are particularly responsive to payment innovations that enhance transaction flow and boost confidence. The secondary sector also benefits, as cashless systems improve supply chain

operations, enable automated settlements, and facilitate digital credit solutions such as embedded finance. As Benhabib and Spiegel (2000) note, financial development enhances investment and productivity through improved information flow and capital allocation mechanisms increasingly embedded in digital payment infrastructure used by SMEs and manufacturers. These dynamics suggest that cashless payments exert the strongest economic impact in service- and industry-oriented sectors. Therefore, we put our hypothesis 3 as below:

H3: The economic growth effects of cashless payment systems are more pronounced in the secondary and tertiary sectors.

Cashless payment systems may generate greater economic returns in financially underdeveloped regions, where traditional banking infrastructure is limited and the marginal utility of digital finance is higher. Digital tools like mobile wallets or QR-based systems can substitute for formal financial institutions by enabling credit access, reducing transaction costs, and smoothing consumption. Clemens and McKenzie (2018) highlight how financial innovations such as remittances have stronger effects where formal credit channels are weak but face empirical detection issues due to aggregation. Similarly, Ouyang (2022) shows that platforms like Alipay expand credit access for underserved users in China through digital footprints. This "leapfrogging" dynamic, where digital finance bypasses conventional financial development stages, is especially salient in emerging markets (Suri & Jack, 2016; Andrianaivo & Kpodar, 2011). These findings suggest that digital payments can yield disproportionately positive growth effects in regions with underdeveloped financial systems.

H4: The growth-enhancing effect of cashless payments is stronger in financially underdeveloped regions.

3. Research design

3.1 Estimation strategy

In our estimation model, we follow the empirical strategy of Huang et al. (2023) by

employing a change-on-change (first-difference) regression design[2], where both the dependent and key independent variables are expressed in growth rates. This approach is particularly suitable for examining the dynamic relationship between cashless payment adoption and economic growth, as it effectively removes unobserved time-invariant heterogeneity across regions and mitigates concerns of spurious correlation driven by level effects. Moreover, by focusing on variations over time, the model captures the marginal impact of changes in digital payment usage on real GDP growth, aligning closely with the theoretical emphasis on transitional dynamics rather than long-run equilibrium levels.

The baseline model specification is:

$$y_{i,t} = \beta_0 + \beta_1 * CashlessPayment_{i,t} + \beta_2 * Controls_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t} \quad (1)$$

Where $y_{i,t}$ is the quarterly growth rate of real GDP in province *i* at time *t*. Cashless-payment variables include notes, cards, and other retail instruments. Rather than referring to payments expressed in absolute terms as the total value of transactions, we follow Pang et al. (2022) and Wong et al. (2020) by using the growth rate of each instrument usage. $Controls_{i,t}$ represents the matrix of various macroeconomic indicators, and $\varepsilon_{i,t}$ is the error term. Province and quarter fixed effects are included. We use province-fixed effects to control for province-level time-invariant factors, while quarter-fixed effects will account for time-specific variation in the outcome variable that cannot be explained by other covariates. Following Zhang et al. (2019), standard errors are robust to heteroskedasticity.

Further, we also develop a toy model of technological growth to characterize the impact of cashless payment expansion on economic growth. The model assumes that economic output is determined by labor input and the level of technology and shown in Appendix C.

3.2 Data and summary statistics

We focus on the growth rates of the following cashless payment methods: notes,

[2] Huang et al. (2023) adopt a change-on-change specification in their Table 4, where they regress GDP growth on changes in thermal infrared radiation (TIR), illustrating the predictive power of anthropogenic production and operating activities on economic outcomes.

bank cards, and other tools. Notes include paper-based payment instruments such as bank drafts, promissory notes, and other negotiable instruments. These are traditional non-cash payments that often involve paper clearing processes. Bank cards include transactions made via debit cards and credit cards, covering point-of-sale purchases and ATM withdrawals. Bank card usage reflects both consumer payments and cash withdrawals using cards, representing a major component of modern retail payments in China. Other tools comprise various electronic and advanced payment methods, including credit transfers, direct debits, collections with acceptance, and letters of credit[3]. In practice, this captures a wide array of digital payments, notably those made through online banking, mobile payment platforms, and other fintech services. The last two are electronic payment instruments that boost the efficiency of payment systems, while notes are traditional to some extent.

The data on non-cash payment instruments are clearing-level transaction records derived from the People's Bank of China (PBoC) between 2017 and 2023 for the 31 provinces in China. This dataset includes the complete set of payment instruments processed through the national clearing and settlement system. Because the data reflects actual cleared transactions rather than survey-based or bank-reported aggregates, they allow a more accurate assessment of payment activity across regions and over time.

To maximize the number of observations available from the non-cash payment dataset and to comprehensively capture the emerging trends over the sample period, we primarily extract the transaction information at the quarterly frequency. After removing data with missing observations and methodological changes in data recording, the final series comprises 651 observations that contain both the amount and the number of transactions.

For each specification, following previous literature (Li et al., 2025), we include a series of control variables to account for initial economic development: the logarithm of GDP amount, lagged GDP growth, the logarithm of population, secondary GDP share, tertiary GDP share, loan balance of financial institutions, GDP amount of building

[3] For example, in 2023, credit transfer transactions accounted for 97% of the total settlement amount of other non-cash payment services.

industry, per capita disposable income growth and per capita consumption expenditure growth. We refer to the Wind Database to obtain data on macroeconomic variables. For a more detailed description of the data, see Appendix Table A1.

Figure 1 depicts the quarterly time series of cashless payment amounts and transaction numbers by instrument type from 2017Q1 to 2023Q1. In Panel A, the total amount of cashless payments shows a steady upward trend, particularly accelerating after 2020. Among the components, other payments exhibit consistent growth and account for the largest share. Card payments rise moderately in recent years, while note-based payments at low levels and exhibit little variation over the sample period.. In Panel B, card transactions consistently record the highest number of transactions throughout the period, reflecting their dominant role in payment frequency. Other payments closely track the rise in total transactions. Overall, the figure highlights both the expansion and the evolving composition of payment activity.

Panel A of Figure 2 shows trends in average transaction prices for each cashless payment instrument, computed as total transaction amount divided by the number of transactions. The total price shows a downward trend and stabilizes at around 10,000 RMB after 2020. Card payments follow a similar decline, with average transaction values falling steadily from above 5,000 to near 2,000 RMB. In contrast, note payments exhibit a sharp increase in average value starting around 2020, peaking near 900,000 RMB. Panel B also presents the year-on-year growth rates of cashless payment amounts. The total growth path is similar to the patterns of card and other electronic payments, which suggests a relatively volatile growth rate in the early period but a mild slowdown after 2021Q1.

Figure 3 illustrates the geographic distribution of average total cashless payment amounts across Chinese provinces. Darker shades represent provinces with higher transaction volumes, while lighter shades indicate lower levels. The map shows that eastern and coastal provinces such as Guangdong, Jiangsu, and Zhejiang fall into the highest quartile ranging from 25.15 to 212.76 trillion RMB, reflecting their advanced financial infrastructure and high economic activity. However, western and some

northeastern regions like Tibet and Qinghai are in the lowest quartile. This spatial pattern highlights significant regional variations in cashless payment penetration.

Figure 4 reflects the decomposition of cashless payment instruments across Chinese provinces over the sample period. In most provinces, other cashless payments account for a dominant share, exceeding 50%. Card payments account for the second-largest share in most regions, with noticeable variation. For example, provinces like Hebei, Ningxia, and Hainan display relatively high card usage proportions. Note-based payments consistently account for a small share, typically below 10%. This chart reveals substantial inter-provincial differences in payment structure.

Table 1 reports summary statistics for the sample. In Panel A and Panel B, we report the summary statistics of each cashless payment measure and macroeconomic variable. In Panel C, we report the pairwise correlation between main variables. *GDP Growth* is a province's year-on-year real GDP growth rate in year-quarter *t*. *Cashless Payment Growth* (i.e., total/note/card/others growth) also represents the province's year-on-year growth rate for each instrument at the year-quarter level. *Secondary Share and Tertiary Share* represent the shares of the GDP captured by the secondary sector and the tertiary sector. *Log (GDP)* and *Log* (*Population*) are the local total GDP and population, respectively. We also include the loan condition (*Loan/GDP*), infrastructure investment (*Build/GDP*), income (*Income Growth*), and consumption dynamics (*Consumption Growth*). All the variables are measured at the end of quarter *t,* except the *Log* (*Population*), which proxies for the population size in the previous year. All continuous variables are winsorized at the 1% level for both tails.

The average GDP growth rate is 7.39% with a standard deviation of 9.36%, indicating high cross-sectional dispersion. The year-on-year growth rate of card and other payments shows positive average growth (4.02% and 4.63%), while note payments decline on average (-12.33%). In terms of transaction counts, card payments grew fastest (19.74%), and note payments declined most sharply (-16.81%). Moreover, average transaction price (amount per transaction) with card payments showing the steepest decline (-12.38%) and note payments increasing substantially (7.03%), which

implies the large-value transfers via notes. Moreover, the average transaction price declines over time, with card payments experiencing the steepest decrease of 12.38%, while note-based payments increase by 7.03%. This pattern suggests a growing concentration of higher-value transactions in note-based payments, alongside the increasing penetration of card payments into smaller transactions.

Panel C shows that GDP Growth is positively and significantly correlated with *Total Growth* (correlation = 0.29). The association is stronger for *Card Growth* (correlation = 0.41) and *Other Growth* (correlation = 0.21), while the correlation with *Note Growth* (correlation = 0.14) is comparatively weak. The correlation matrix suggests that growth in cashless payments, particularly card-based payments, is strongly related to GDP growth.

4. Empirical results

This section presents our main findings. Section 4.1 documents the structural determinants of provincial cashless payment growth. Section 4.2 estimates panel regressions linking cashless payment growth to provincial GDP. Section 4.3 examines sectoral heterogeneity in these growth effects. To address endogeneity concerns, Section 4.4 implements an instrumental-variable strategy based on social trust and terrain ruggedness. Section 4.5 explores heterogeneity by financial infrastructure and geographic distribution. Section 4.6 investigates the underlying mechanisms, focusing on payment efficiency and financial inclusion channels. Finally, Section 4.7 provides additional evidence on other economic outcomes.

4.1 Determinants of cashless payment growth

Before turning to the causal effects of cashless payment adoption on economic performance, we first examine the structural determinants of cashless payment growth across provinces. Table 2 reports cross-sectional regressions where the dependent variable is the average quarterly growth rate of cashless payments between 2017Q1 and 2023Q1, and we fix all the independent variables at their values at the end of the year 2016. We find that provinces with higher population, stronger secondary and tertiary

sector shares, and higher consumption levels exhibit faster growth in cashless payments. Conversely, larger economic scale and greater loan to GDP ratios are negatively associated with cashless payment growth, suggesting a saturation effect in more financially developed regions. Pre-determined financial inclusion level is positively related to the growth of cashless payments, consistent with the notion that financial access and digital adoption are mutually reinforcing.

These findings confirm substantial heterogeneity in the diffusion of cashless systems and provide a structural basis for the growth effects analyzed in subsequent sections.

4.2 Baseline results

To evaluate H1, Table 3 first estimates the baseline relationship between overall cashless payment growth and provincial GDP growth. This specification assesses whether provinces experiencing faster expansion in cashless payments also exhibit stronger economic performance, after accounting for province and quarter fixed effects and standard controls. Because H1 predicts a positive association between cashless payment penetration and growth, this baseline model provides the primary empirical test. To evaluate H2, Table 3 decomposes cashless payment growth into its main components: notes, cards, and other electronic instruments. If the growth effect operates primarily through more traceable and credit-integrated channels, card-based payment growth should display the strongest association with GDP growth. Growth in paper-based note instruments relies on slower and less digitized clearing mechanisms and is therefore expected to be weaker or statistically insignificant. This decomposition quantifies the relative contribution of different clearing-level payment streams and offers a mechanism-oriented test of H2.

Table 3 reports the baseline results examining the relationship between cashless payment growth and provincial GDP growth[4]. For column (1) and (2), we estimate a panel regression specification where the only payment-related explanatory variable is

[4] Before showing the baseline result, Appendix Figure B1 plots provincial quarterly-average GDP growth against cashless payment amount growth over 2017Q1 – 2023Q1. The fitted line is upward sloping (y=6.94+0.32x), suggesting a modest positive association: provinces such as Guangdong, Zhejiang, and Beijing cluster in the upper-right, whereas Jilin, Hebei, and Liaoning concentrate in the lower-left.

the total year-on-year growth rate of cashless payments. In the specification without any control variables reported as column (1), the coefficient on *Total Growth* is 0.115 and statistically significant at the 5% level. When a set of control variables are included, the coefficient declines to 0.086 while remaining statistically significant, indicating that a 10 percentage point increase in overall cashless payment growth is associated with a 0.86 percentage point increase in GDP growth[5]. This corresponds to a GDP increase of approximately RMB 1.95 billion.

For columns (3) to (6), we disaggregate the total payment into the three major payment components: notes, cards, and others. Column (4) highlights that *Card Growth* is strongly and positively associated with GDP growth, with a coefficient of 0.191, significant at the 1% level. This effect remains robust and significant in column (6) when other components are jointly included. In contrast, *Note Growth* shows no significant impact and even turns negative in column (6), while other cashless payments exhibit a marginally significant effect.

Control variables behave as expected: the coefficients on *Log (GDP)* and *Lagged GDP Growth* are negative and highly significant, reflecting mean reversion and size effects. *Income Growth* is positively and significantly correlated with GDP growth throughout all specifications. The shares of tertiary industry, loan-to-GDP, and investment (*Build/GDP*) consistently show negative associations with GDP growth, which may reflect structural or capital misallocation effects in the sample period.

In Appendix Table A2, we report the robustness test of baseline results. We re-estimate the regressions above using a binary dependent variable equal to 1 if a province's GDP growth in a given quarter exceeds the cross-sectional median, and 0 otherwise. This approach assesses whether cashless payments are systematically associated with being in the upper half of the provincial growth distribution. In column (1), *Total Growth* is positively and significantly associated with the likelihood of above-median GDP growth. Columns (2)-(4) examine the role of individual payment instruments. The coefficients on *Note Growth* (0.010), *Card Growth* (0.026), and

[5] An increase in overall cashless payment growth by one standard deviation is associated with a 0.924 percentage point increase in GDP growth, corresponding to approximately 12.5% of the mean GDP growth rate across provinces.

Others Growth (0.010) are all positive and statistically significant at the 1% level, respectively. In the robustness test, the coefficient on cashless payment growth continues to be similar to that in the main specification.

As a supplementary decomposition (reported in Appendix Table A3), we examine whether the GDP effects operate through transaction frequency (number growth) or transaction intensity (average price growth). The results indicate that both margins contribute for aggregate cashless payments, but the channel is concentrated in card-based instruments: card transaction number growth is significantly positive, and card transaction price growth is even larger and highly significant across specifications. These findings reinforce Table 3 by showing that the macroeconomic gains from cashless expansion are driven primarily by higher-price card transactions, rather than a mere increase in low-price transaction counts.

Overall, the results reported in Table 3 show that the expansion of card-based cashless payments is a key contributor to regional economic growth, while note-based payments play a negligible role.

4.3 Decomposing GDP growth by sector

Table 4 examines the sectoral heterogeneity implied by H3, which predicts that the growth effects of cashless payment development are stronger in the secondary (industrial) and tertiary (service) sectors than in the primary sector. The intuition is that sectors characterized by frequent transactions, denser supply chains, and greater reliance on modern payment rails should benefit more from lower settlement frictions and improved liquidity.

To test this prediction, Panel A estimates the impact of overall cashless payment growth on sector-specific GDP growth, assessing whether broad cashless expansion disproportionately benefits the secondary and tertiary sectors. Panels B-D then further decompose the relationship within each sector by payment instrument, notes, cards, and other electronic payments, allowing us to pinpoint which channels drive the observed heterogeneity and to refine the mechanism interpretation underlying H2.

Panel A shows that the coefficient on *Total Growth* is positive across all three

sectors, but statistical significance varies. Specifically, a one percentage point increase in total cashless payment growth is associated with a 0.170 percentage point increase in secondary sector GDP growth and a 0.129 percentage point increase in tertiary sector GDP growth. The coefficient for the primary sector is positive but not statistically significant. Panel A indicates that cashless payment development exerts stronger growth effects in industrial and service-oriented sectors.

Panel B focuses on the primary sector and decomposes the effects by payment type. *Note Growth* is positively associated with primary sector GDP growth, with coefficients of 0.126 (column 1) and 0.111 (column 4), both statistically significant at the 5% level, respectively. This implies that note-based payments—possibly linked to traditional agriculture or rural commerce—play a relatively stronger role in supporting growth in the primary sector. Card and other electronic payments show no significant impact in this segment.

Panel C examines the secondary (industrial) sector. The results show that *Card Growth* has the most robust impact, with coefficients of 0.243 (column 2) and 0.230 (column 4), significant at the 1% and 5% levels, respectively. These findings align with the view that card-based transactions are closely tied to formalized commercial activity and may facilitate production and investment. Note payments show no statistically significant association with industrial growth, whereas other payment types are marginally significant at the 10% level.

Panel D explores the relationship between payment instruments and tertiary sector GDP growth. *Card Growth* again emerges as the dominant driver, with a significant coefficient of 0.163 (column 2) at the 5% level, while *Note Growth* and *Others Growth* remain insignificant. This result underscores the role of card-based transactions in enabling service-sector activity where electronic payments are prevalent.

Taken together, the sectoral decomposition regressions suggest that note-based payments are more closely tied to traditional activities—most notably the primary sector—whereas card payments and other electronic instruments are more strongly associated with growth in modern, higher-value-added sectors (secondary and tertiary).

This pattern is consistent with cashless payment development accompanying, and potentially facilitating, a degree of industrial upgrading. It also echoes the empirical results in Table 3, where the note-based growth term is insignificant, while the card and other payment components remain significantly positive.

4.4 Endogeneity issue

In the previous section, we use the OLS regression with panel data to generate robust findings that there is a significant positive correlation between cashless payment penetration and regional GDP growth. However, such correlations do not necessarily mean that cashless payment has a causal effect on local economic growth. In line with previous literature (Zhang et al., 2019), we also conduct two-stage instrumental variable regressions to address the endogeneity issue. One major endogeneity concern arises from the possibility that the growth rate of non-cash payment is related to economic conditions, especially GDP. For instance, provinces exhibiting higher rates of economic growth may tend to adopt non-cash payment methods more rapidly. Although it is not possible to fully eliminate all sources of endogeneity, we propose two instrumental variables to mitigate its potential impact.

Specifically, we use the proxy of social trust and traditional financial infrastructure that are measured at the provincial level as the key component of instrumental variables for payment methods. On the one hand, existing research has studied how the extent of social trust affects the usage of advanced payment instruments (e.g., Jonker et al., 2022; Zhou, 2014). Zhang et al. (2019) show that people in more trustworthy regions rely more on cashless payment methods and less on cash. On the other hand, the level of social trust does not directly affect economic development, except insofar as it influences the choice of payment means. Hence, following Nunn & Qian (2014), we use the interaction terms between the lagged year-on-year growth rate of total cashless payments and the reciprocal of the two specific social trust proxies (*Trust*) as the instrumental variable *IV1*. *Trust* is the average number of NGOs per 10,000 people at the provincial level over the period 2000-2016 (Wu et al., 2014).

The second instrument (*IV2*) is constructed as the negative interaction between

provincial terrain ruggedness and the quarterly growth rate of total cashless payments (Cui et al., 2023). Rugged terrain historically limits transportation and face-to-face interactions, thereby impeding the spread of traditional banking infrastructure, yet it is plausibly exogenous to near-term GDP dynamics. Hence, more rugged provinces respond differently to nationwide digital payment diffusion because geography shapes the marginal benefit of cashless adoption.

Furthermore, we assess the validity of the instruments using two post-estimation tests. First, we perform the under-identification test using the Kleibergen-Paap rk Lagrange multiplier (LM) statistic. Our results show that both models are strongly identified at the 1% significance level. Second, we conduct the weak identification test to evaluate whether or not our instrumental variables are relevant via the Kleibergen-Paap Wald rk F-statistic. For our models, the F-statistics exceed the conventional 10% critical value threshold, suggesting that both *IV1* and *IV2* are relevant. Together, these tests support that the instruments satisfy the key assumptions of relevance and exclusion restriction.

As shown in Table 5, the odd columns present the results of the first-stage regressions, while the even columns present the second-stage results. In the first two columns, *IV1* is used as the instrument; in the subsequent two columns, *IV2* serves as the instrument; in the last two columns, both instruments are added in the regression. As expected, both instruments are strong predictors of the non-cash payment growth rate. Columns (1) and (3) report that each instrument is highly statistically significant when included separately in the regression. Column (5) shows that when both instruments are included, their significance and economic magnitude are similar to column (1) and (3). In the second stage, the coefficient on *Total Growth* is positive, ranging from 0.387 to 0.474, and statistically significant in both cases. When using either *IV1* or *IV2* instruments or both instruments, the coefficients on *Total Growth* are significantly larger than those from the OLS regression, suggesting that the OLS estimates are downward biased, likely due to a negative correlation between the cashless payment variable and the error term.

In summary, these IV results in Table 5 strengthen the identification of our baseline findings and demonstrate that the relationship between cashless payment adoption and economic growth remains robust when accounting for potential endogeneity.

4.5 Heterogeneous tests: sorted by financial infrastructure

The growth effects of cashless payment adoption should be strongest where traditional financial infrastructure is relatively weak. In less financially developed provinces, higher settlement frictions and limited access to formal intermediation make payment innovations more valuable as substitutes for conventional financial services, particularly when they operate within formal clearing networks and generate verifiable transaction histories[6]. Consequently, if cashless payments relax liquidity constraints and facilitate market participation where traditional channels are sparse, their growth-enhancing effects should be stronger in financially underdeveloped regions, consistent with H4.

To test this prediction, Table 6 examines heterogeneity along two dimensions of provincial financial infrastructure: the degree of financial marketization (Low vs. High FMI) and geographic location (East vs. Middle & West).

Panel A explores heterogeneity in the impact of cashless payment growth on GDP by splitting the sample based on provincial levels of financial marketization[7]. The results reveal that the effects are concentrated in provinces with low financial market development (*LowFMI*). In this subsample, *Card Growth* has a significant and substantial impact on GDP growth (0.238), while little effect is observed in *HighFMI* regions. The coefficient difference (0.141) is also significant, suggesting that cashless payment adoption may be more growth-enhancing where traditional financial markets are less developed. Similarly, the effect of other payments is positive and significant only in *LowFMI* areas (0.096), and the group difference (0.127) is also significant at

[6] Prior research documents that such innovations have disproportionately positive effects in environments with weak financial intermediation, as digital finance allows users to "leapfrog" conventional development stages and access financial services that would otherwise be unavailable (Suri & Jack, 2016; Andrianaivo & Kpodar, 2011).

[7] The marketization index developed by Wang et al. (2017) provides a comprehensive measure of market-oriented reforms across Chinese provinces, covering dimensions such as government–market relations, development of non-state sectors, and factor market liberalization. The index is compiled in a research report that has been updated biennially since its inception.

the 1% level. The total cashless effect is large and significant (0.171) in *LowFMI* provinces but null in *HighFMI* ones.

Panel B presents a similar analysis distinguishing province in the eastern region from those in the central and western regions as a proxy for the level of development of financial infrastructure[8]. Provinces with less developed financial infrastructure (*Middle & West*) exhibit stronger effects of cashless payment growth on GDP. The coefficient for other payments is 0.074 in *Middle & West* regions, compared to -0.067 in *East* regions, with a statistically significant difference of 0.141. Card payments remain significant in both *East* and *Middle & West* groups, with a larger effect observed in the latter. However, the between-group variation (0.059) is statistically insignificant. These results reflect those cashless payments may have stronger economic effects where physical financial services are limited.

Together, the findings in Table 6 indicate that marginal improvements in payment accessibility tend to yield stronger economic returns in financially underdeveloped regions, particularly for card-based and other caseless instruments, underscoring their potential to promote inclusive growth and close infrastructure gaps with much higher marginal effect.

4.6 Mechanism

To further investigate the mechanism through which cashless payments may influence economic growth, we focus on payment efficiency and financial inclusion channel (Agarwal et al., 2012; Ouyang, 2023).

4.6.1 Payment efficiency channel

To further assess whether lower trading costs and higher payment efficiency constitute a key channel through which cashless payments foster growth, we conduct two complementary tests.

First, we replace the dependent variable with transaction volume per capita to examine whether the expansion of cashless payments is associated with greater transaction intensity. The results, reported in Table 7**,** show that cashless payment

[8] https://www.stats.gov.cn/zt_18555/zthd/sjtjr/d12kfr/tjzsqzs/202302/t20230216_1908940.html

growth is positively related to transaction volume per capita (0.160), with the effect largely driven by card transactions (0.423). This pattern suggests that payment digitalization translates into more transactions per person, consistent with improved market liquidity and lower effective transaction costs.

Second, we interact cashless payment growth with the logarithm of bank branches per capita measured in 2016, which proxies for the availability of traditional financial infrastructure. If cashless payments substitute for physical banking access, their growth impact should be stronger where branch networks are sparse. As shown in Appendix Table A4, the interaction term between cashless payment growth and branch density is negative across specifications and is statistically significant for card payments (–0.060, $p<0.05$). This implies that the growth-enhancing effect of card-based payments is amplified in regions with weaker branch coverage, consistent with the view that digital payments reduce settlement frictions and partially substitute for conventional financial access. The total cashless and other payment categories display the same negative sign, albeit with weaker statistical significance.

Together, these regressions provide consistent, suggestive evidence that the payment-efficiency channel helps link cashless payment adoption to economic growth. The substitution between digital and physical financial infrastructure, combined with the intensification of transaction activity, indicates that improvements in payment efficiency are an important mechanism through which cashless systems support real economic performance. This interpretation is in line with the theoretical predictions of New Monetarist Economics (Williamson & Wright, 2010) and the financial development literature (Levine, 2005), both of which emphasize the central role of payment mechanisms in resource allocation and output. Our findings are also consistent with Agarwal et al. (2025), who show that the adoption of mobile payment platforms in China reduces transaction and liquidity costs, boosts firm-level output, and accelerates aggregate economic activity.

4.6.2 Financial inclusion channel

A second mechanism through which cashless payments may foster economic growth operates via financial inclusion. Digital and cashless payment systems can act

as a gateway to formal finance by providing low-cost transaction accounts, building digital footprints that substitute for conventional collateral, and facilitating savings, credit, and insurance participation for small businesses and households that were previously excluded from the banking sector.

We examine this channel using three complementary approaches. First, we test whether the inclusion effect varies with rural financial access in Table 8. By interacting cashless payment growth with the rural population share, we find that the interaction coefficients are positive across all specifications and statistically significant for total, note, and other payments, implying that digital payment expansion generates stronger economic effects in more rural provinces.

Second, we explore the role of human capital barriers to inclusion by interacting cashless payment growth with the share of the population without formal education. As reported in Table 9, the interaction terms are uniformly positive and significant across all payment types, suggesting that digital payment systems can help relax informational and educational constraints that traditionally hinder financial participation.

Third, we conduct a subsample analysis based on the level of provincial financial inclusion in 2016. Provinces are classified into low- and high-inclusion (*Low FI* and *High FI*) groups using the Peking University Digital Financial Inclusion Index. Appendix Table A5 shows that the positive association between cashless payment growth and GDP growth is concentrated in low-inclusion provinces, where digital financial services substitute for limited physical banking infrastructure. In these provinces, a one percentage point increase in total cashless payment growth is associated with a 0.161 percentage point increase in GDP growth, whereas the coefficient is insignificant and slightly negative in high-inclusion provinces. Disaggregating by payment instrument reinforces this pattern: in low-inclusion regions, card-based transactions exhibit the strongest impact on economic growth (0.222), followed by other digital payments (0.072) and note payments (0.063).

Finally, we examine whether cashless payment growth is associated with changes in provincial income inequality, measured by the Gini index. Table 10 shows that total

cashless payment growth is negatively related to the Gini coefficient (-0.127, significant at the 5% level), indicating that faster payment digitalization is linked to more equal income distributions. This effect is primarily driven by other payments, which display a modest and marginally significant coefficient of -0.062, whereas note- and card-based components are insignificant. These patterns suggest that, consistent with the financial inclusion mechanism, expanded access to digital payments tends to narrow income gaps while raising aggregate economic activity.

Overall, these findings provide robust evidence that the financial inclusion channel is a central mechanism linking cashless payment growth to real economic activity. They show that payment innovations disproportionately benefit more rural, less educated, and financially underdeveloped provinces, and are also associated with lower income inequality. Together, these patterns highlight that improvements in payment methods not only enhance transactional efficiency, but also broaden the base of economic participation and contribute to a more inclusive and sustainable growth process. This interpretation is consistent with Beck et al. (2022), as well as with the broader literature arguing that more equal income distributions foster longer and more stable growth spells (Persson & Tabellini, 1994; Alesina & Rodrik, 1994; Bénabou, 1996; Berg & Ostry, 2011), and with micro evidence from Agarwal et al. (2025) on the real effects of mobile payments in China.

4.7 Further test

We also provide additional evidence to demonstrate the impact of cashless payment growth on other economic outcomes. Specifically, we investigate the following outcomes: overall tax revenue growth, enterprise income tax growth, individual income tax growth, log number of new firms, fixed asset investment growth (excluding households). Using province-level average value over 2018–2022, we estimate cross-sectional regressions of five outcome variables on overall cashless payment growth.

Appendix Figure B2 shows the results. Panel A shows that cashless payment growth is positively associated with overall tax revenue growth, with a slope coefficient of 0.46 significant at the 5% level (R^2=0.20), suggesting that provinces with faster

expansion in cashless transactions tend to experience stronger fiscal revenue growth (Noman et al., 2023). Disaggregating tax categories, Panel B indicates a positive but statistically insignificant association with enterprise income tax growth, whereas Panel C reports a strong and significant association with individual income tax growth (coefficient 0.70, significant at the 1% level, R^2=0.35), implying that the fiscal impact of cashless payments is more pronounced on personal taxation.

Turning to enterprise development, Panel D reveals that cashless payment growth is significantly related to the log number of new firms ($p<0.01$), suggesting a positive association with firm entry. Finally, Panel E shows a positive and significant relationship with fixed asset investment growth (excluding households), with a coefficient of 0.31 significant at the 1% level (R^2=0.14), indicating that provinces with higher cashless payment growth also exhibit stronger investment dynamics.

Overall, these results reinforce the view that the expansion of cashless payments not only supports fiscal capacity but also fosters enterprise creation and capital formation at the macroeconomic level.

5 Conclusion

Using a province–quarter panel for 2017–2023 built from clearinghouse transactions, we show that the diffusion of cashless payments meaningfully raises provincial real GDP growth. First, growth in card-based non-cash payments is significantly associated with higher real GDP growth, particularly when measured by transaction value. This relationship remains robust under alternative estimation strategies, including an instrumental variable approach that accounts for potential endogeneity in payment adoption. The IV estimates reveal that overall cashless payment growth exerts a significantly larger positive impact on GDP than OLS results suggest, consistent with a causal interpretation. This reinforces the role of card-based transactions but also highlights the aggregate contribution of non-cash adoption to economic activity. In contrast, note-based and certain other electronic tools exhibit weaker or statistically insignificant effects, underscoring the need to distinguish among

payment modalities when evaluating economic outcomes.

Second, we identify clear sectoral heterogeneity. The positive effects of card-based payments are concentrated in the secondary and tertiary sectors, where digital and formal financial services are more embedded. In contrast, note-based payments remain more relevant in the primary sector, reflecting the persistence of cash-intensive practices in agriculture and rural markets.

Third, we uncover substantial heterogeneity across institutional and temporal contexts. The heterogeneity tests show that card-based and other electronic payments have particularly strong effects in provinces with underdeveloped financial infrastructure, while their impact is negligible in financially advanced regions. This suggests that digital payment adoption yields higher marginal growth benefits precisely where traditional banking services are scarce.

The evidence points to two reinforcing mechanisms. First, we identify a payment-efficiency channel: both the frequency of transactions and their average ticket size predict higher GDP growth, with the effects most pronounced for card-based volume and pricing. Provinces undergoing rapid cashless expansion also record more transactions per capita, consistent with reduced frictions in exchange and settlement. Second, we document an inclusion channel: the growth effects are significantly larger where traditional finance is thin, represented by low financial marketization, lower bank branch density, higher rural population shares, and lower educational attainment. These findings imply high marginal returns to digital payment rails in underserved markets, where they effectively substitute for physical banking services.

Beyond these empirical contributions, our findings offer broader implications for the evolving global payment landscape. China’s experience illustrates that the transition from cash to non-cash systems is not always a zero-sum process; rather, it often proceeds through a dynamic of "incremental substitution", in which digital and traditional payment modes coexist and expand in tandem under conditions of economic growth. This insight challenges the conventional assumption that digital finance necessarily reduces the cash in circulation, and instead highlights a more complex

reality in which payment innovation facilitates broader monetary activation.

In the context of the worldwide shift toward stablecoins, central bank digital currencies (CBDCs), and crypto-based payment systems, our study underscores several critical lessons. First, successful digital payment systems require more than technological innovation—they must be embedded in reliable institutional infrastructure, supported by regulation, trust, and interoperability. Second, the heterogeneous uptake of cashless tools across Chinese provinces parallels global asymmetries in digital readiness, with underbanked regions having both the most to gain and the greatest implementation challenges. Third, the capacity of digital payments to enable inclusive consumption and macroeconomic resilience, especially in times of crisis, positions them as a key policy lever for promoting sustainable and equitable development in the digital age.

From a policy perspective, these findings suggest the value of prioritizing the rollout of card-based and interoperable digital payment ecosystems, particularly in regions with limited access to physical banking. Regulators should focus on building secure, trusted, and widely accepted platforms that enhance financial access while safeguarding against volatility and exclusion. As new forms of programmable money emerge globally, the Chinese case offers a cautious but hopeful roadmap. It shows that digital finance, when supported by strong institutions and adaptive policy, can play an important role in shaping future economic growth.

Future research should examine the long-term welfare effects of digital payment diffusion. Key areas include firm productivity, tax compliance, shadow economy reduction, and labor market formalization. As public, private, and decentralized monetary instruments increasingly overlap, researchers and policymakers need a clearer understanding of payment dynamics in different contexts.

References

Beck, T., & Demirguc-Kunt, A. (2006). Small and medium-size enterprises: Access to finance as a growth constraint. *Journal of Banking & Finance*, *30*(11), 2931–2943. https://doi.org/10.1016/J.JBANKFIN.2006.05.009

Beck, T., Gambacorta, L., Huang, Y., Li, Z., & Qiu, H. (2022). Big techs, QR code payments and financial inclusion. *BIS Working Papers*, *May 2022*(1011), 1–47. www.bis.org

Ben Zeev, N. (2021). *The TFP Channel of Credit Supply Shocks* *.

Benhabib, J., & Spiegel, M. M. (2000). The Role of Financial Development in Growth and Investment. In *Journal of Economic Growth* (Vol. 5).

Campo, F., Nunziata, L., & Rocco, L. (2024). Business is tense: new evidence on how language affects economic activity. *Journal of Economic Growth*, *29*(1), 121–149. https://doi.org/10.1007/s10887-023-09229-5

Cinnirella, F., & Streb, J. (2017). The role of human capital and innovation in economic development: evidence from post-Malthusian Prussia. *Journal of Economic Growth*, *22*(2), 193–227. https://doi.org/10.1007/s10887-017-9141-3

Clemens, M. A., & McKenzie, D. (2018). Why Don't Remittances Appear to Affect Growth? *Economic Journal*, *128*(612), F179–F209. https://doi.org/10.1111/ecoj.12463

Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband Infrastructure and Economic Growth. *Economic Journal*, *121*(552), 505–532. https://doi.org/10.1111/j.1468-0297.2011.02420.x

Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2018). The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. *The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution*. https://doi.org/10.1596/978-1-4648-1259-0

Dincecco, M., & Katz, G. (2016). State Capacity and Long-run Economic Performance. *Economic Journal*, *126*(590), 189–218. https://doi.org/10.1111/ecoj.12161

Dincecco, M., & Prado, M. (2012). Warfare, fiscal capacity, and performance. *Journal of Economic Growth*, *17*(3), 171–203. https://doi.org/10.1007/s10887-012-9079-4

Doepke, M., & Tertilt, M. (2019). Does female empowerment promote economic development? *Journal of Economic Growth*, *24*(4), 309–343. https://doi.org/10.1007/s10887-019-09172-4

Dubey, T. S., & Purnanandam, A. (2023). Can Cashless Payments Spur Economic Growth? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4373602

Galiani, S., Knack, S., Xu, L. C., & Zou, B. (2017). The effect of aid on growth: evidence from a Quasi-experiment. *Journal of Economic Growth*, *22*(1), 1–33. https://doi.org/10.1007/s10887-016-9137-4

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2004). Do institutions cause growth? *Journal of Economic Growth*, *9*(3), 271–303. https://doi.org/10.1023/B:JOEG.0000038933.16398.ed

Greenwood, J., & Jovanovic, B. (1990). Financial Development, Growth, and the Distribution of Income. *Https://Doi.Org/10.1086/261720*, *98*(5, Part 1), 1076–1107. https://doi.org/10.1086/261720

Halter, D., Oechslin, M., & Zweimüller, J. (2014). Inequality and growth: The neglected time dimension. *Journal of Economic Growth*, *19*(1), 81–104. https://doi.org/10.1007/s10887-013-9099-8

Henderson, V. (2003). The urbanization process and economic growth: The so-what question. *Journal of Economic Growth*, *8*(1), 47–71. https://doi.org/10.1023/A:1022860800744

Higgins, S. (2024). Financial Technology Adoption: Network Externalities of Cashless Payments in Mexico. *American Economic Review*, *114*(11), 3469–3512. https://doi.org/10.1257/aer.20201952

Huang, F., Zhang, B., & Zhao, X. (2023). *The Thermodynamics of the Economy*.

Jack, W., & Suri, T. (2014). Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution. *American Economic Review*, *104*(1), 183–223. https://doi.org/10.1257/aer.104.1.183

Jonker, N., van der Cruijsen, C., Bijlsma, M., & Bolt, W. (2022). Pandemic payment patterns. *Journal of Banking and Finance*, *143*. https://doi.org/10.1016/j.jbankfin.2022.106593

Kalaitzidakis, P., Mamuneas, T. P., & Savvides, A. (2001). Measures of Human Capital and Nonlinearities in Economic Growth. In *Journal of Economic Growth* (Vol. 6).

Kpodar, K. R., & Andrianaivo, M. (2011). ICT, Financial Inclusion, and Growth: Evidence from African Countries. *IMF Working Papers*, *2011*(073). https://doi.org/10.5089/9781455227068.001.A001

Lagerlo, N. (2003). Gender Equality and Long-Run Growth. *Journal of Economic Growth*, *8*, 403–426.

Levine, R. (1999). Law, Finance, and Economic Growth. *Journal of Financial Intermediation*, *8*(1–2), 8–35. https://doi.org/10.1006/jfin.1998.0255

Levine, R. (2005). Chapter 12 Finance and Growth: Theory and Evidence. *Handbook of Economic Growth*, *1*(SUPPL. PART A), 865–934. https://doi.org/10.1016/S1574-0684(05)01012-9

Lucas, R. E., & Stokey, N. L. (1987). Money and Interest in a Cash-in-Advance Economy. *Econometrica*, *55*(3), 491. https://doi.org/10.2307/1913597

Neidhöfer, G., Ciaschi, M., Gasparini, L., & Serrano, J. (2024). Social mobility and economic development. In *Journal of Economic Growth* (Vol. 29, Issue 2). Springer US. https://doi.org/10.1007/s10887-023-09234-8

Nunn, N., & Qian, N. (2014). US food aid and civil conflict. *American Economic Review*, *104*(6), 1630–1666. https://doi.org/10.1257/aer.104.6.1630

Ong, H. B., & Chong, L. L. (2023). The effect of cashless payments on the internet and mobile banking. *Journal of Financial Services Marketing*, *28*(1), 178–188. https://doi.org/10.1057/s41264-022-00145-0

Ouyang, S. (2023). *Cashless Payment and Financial Inclusion*.

Özak, Ö. (2018). Distance to the pre-industrial technological frontier and economic development. *Journal of Economic Growth*, *23*(2), 175–221. https://doi.org/10.1007/s10887-018-9154-6

Posch, O., & Wälde, K. (2011). On the link between volatility and growth. *Journal of Economic Growth*, *16*(4), 285–308. https://doi.org/10.1007/s10887-011-9069-y

Schularick, M., & Solomou, S. (2011). Tariffs and economic growth in the first era of globalization. *Journal of Economic Growth*, *16*(1), 33–70. https://doi.org/10.1007/s10887-011-9061-6

Silva, T. C., Hasan, I., & Tabak, B. M. (2021). Financing choice and local economic growth: evidence from Brazil. *Journal of Economic Growth*, *26*(3), 329–357. https://doi.org/10.1007/s10887-021-09191-0

Singh Dubey, T., Purnanandam, A., Agarwal, R., Atkenson, A., Chordia, T., Duffie, D., Ghosh, P., Gine, X., Gupta, A., Gupta, N., Higgins, S., John, K., Kim, E., Krishnamurthy, A., Krishna, P.,

Malenko, A., Malenko, N., Matvos, G., Manchanda, P., … Zeng, Y. (2023). Johns Hopkins Carey Finance Conference, 2023, NBER meeting on Capital Markets, Technology, Financial Inclusion, & Economic Growth, 2023, NBER Macro, Money and Financial Frictions, SI 2023, Payments & Securities Settlement Workshop, Bank of Canada. In *SITE Financial Regulation*. https://ssrn.com/abstract=4373602

Suri, T., & Jack, W. (2016). The long-run poverty and gender impacts of mobile money. *Science*, *354*(6317), 1288–1292. https://doi.org/10.1126/SCIENCE.AAH5309/SUPPL_FILE/SURI.SM.PDF

Tan, W., Tang, Q., Sun, W., & Du, X. (2025). Unintended consequences: Examining the effects of government digital regulation on corporate fintech innovation in China. *Emerging Markets Review*, *64*. https://doi.org/10.1016/j.ememar.2024.101221

Tang, L., Xuan, Y., & Zou, H. (2022). Does Mobile Payment Adoption Reduce Corruption? Cross-country Evidence. *SSRN Electronic Journal*. https://doi.org/10.2139/SSRN.4163262

Tee, H. H., & Ong, H. B. (2016). Cashless payment and economic growth. *Financial Innovation*, *2*(1), 1–9. https://doi.org/10.1186/s40854-016-0023-z

Voitchovsky, S. (2005). Does the profile of income inequality matter for economic growth?: Distinguishing between the effects of inequality in different parts of the income distribution. *Journal of Economic Growth*, *10*(3), 273–296. https://doi.org/10.1007/s10887-005-3535-3

Williamson, S., & Wright, R. (2010). *New Monetarist Economics* (pp. 25–96). https://doi.org/10.1016/B978-0-444-53238-1.00002-8

Wisniewski, T. P., Polasik, M., Kotkowski, R., & Moro, A. (2024). Switching from Cash to Cashless Payments during the COVID-19 Pandemic and Beyond *. In *International Journal of Central Banking* (Vol. 20, Issue 3).

Wong, T. L., Lau, W. Y., & Yip, T. M. (2020a). Cashless Payments and Economic Growth: Evidence from Selected OECD Countries. *Journal of Central Banking Theory and Practice*, *9*, 189–213. https://doi.org/10.2478/jcbtp-2020-0028

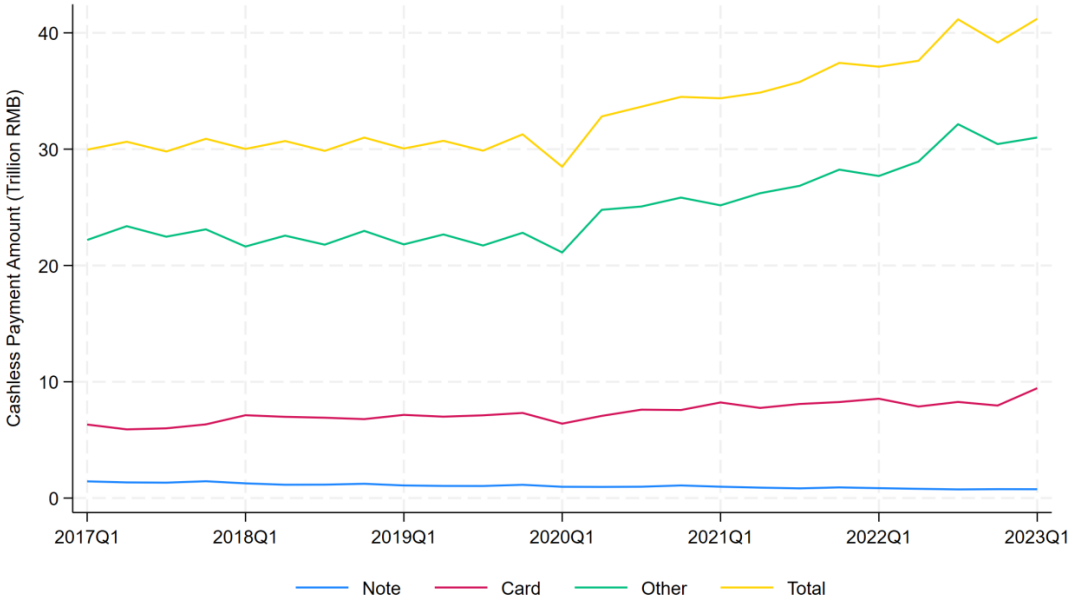
Wong, T. L., Lau, W. Y., & Yip, T. M. (2020b). Cashless Payments and Economic Growth: Evidence from Selected OECD Countries. *Journal of Central Banking Theory and Practice*, *9*, 189–213. https://doi.org/10.2478/jcbtp-2020-0028

Zhang, Y., Zhang, G., Liu, L., De Renzis, T., & Schmiedel, H. (2019). Retail payments and the real economy. *Journal of Financial Stability*, *44*. https://doi.org/10.1016/j.jfs.2019.100690

Zhou, T. (2014). An empirical examination of initial trust in mobile payment. *Wireless Personal Communications*, *77*(2), 1519–1531. https://doi.org/10.1007/s11277-013-1596-8

Zins, A., & Weill, L. (2016). The determinants of financial inclusion in Africa. *Review of Development Finance*, *6*(1), 46–57. https://doi.org/10.1016/J.RDF.2016.05.001

Panel A: Cashless Payment Amount



Panel B: Cashless Payment Transaction Number

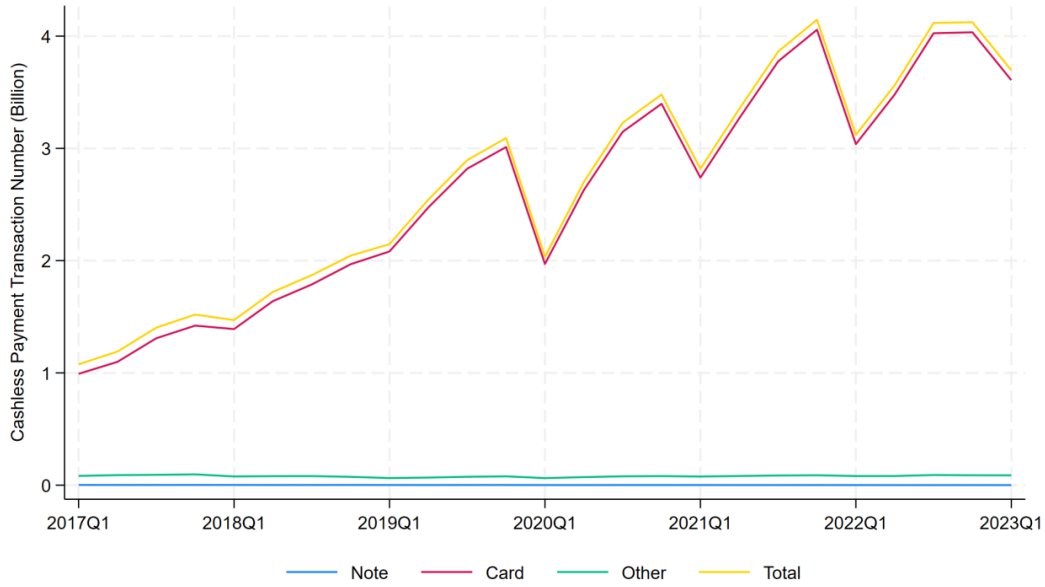
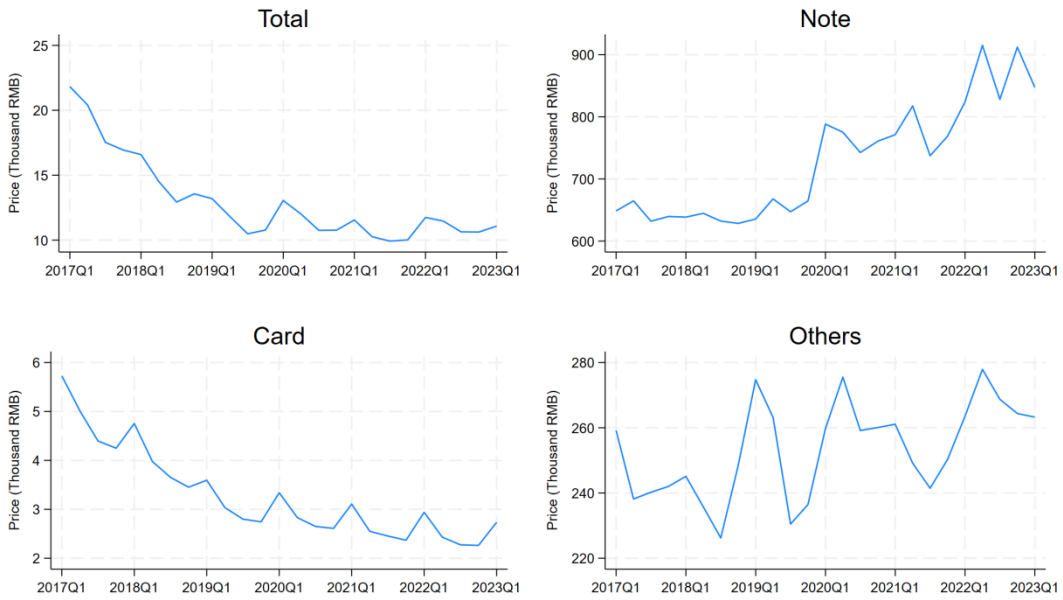


Figure 1. Time Series for the Volume of Cashless Payment

This figure illustrates the volume dynamics (amount and transaction number) of note-based, card-based, and other instruments in total cashless payment across time from 2017Q1 to 2023Q1. The yellow line represents the total amount of cashless payments across all instruments, the green line corresponds to other payments, the red line denotes card payments, and the blue line shows note-based payments.

Panel A: Cashless Payment Transaction Price



Panel B: Cashless Payment Amount Growth

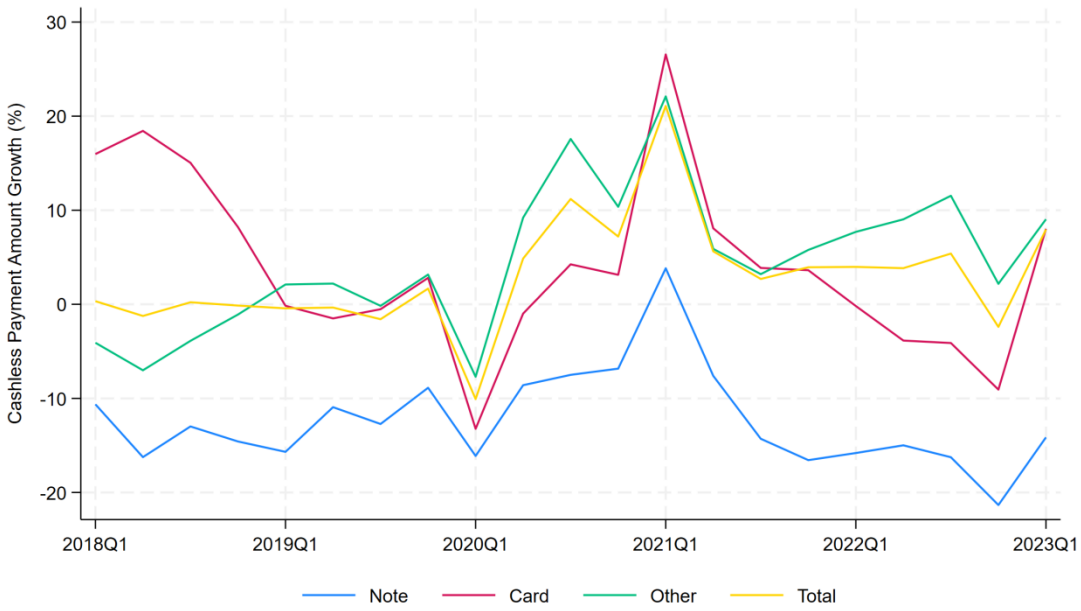


Figure 2. Time Series for Other Cashless Payment Metrics

This figure plots the average transaction price and growth rate of various cashless payment types. In Panel A, the top left displays the average transaction price for total cashless payments. The top right, bottom left, and bottom right show the average transaction value for note-based, card-based, and other payments, respectively. In Panel B, the yellow line represents the total amount growth of cashless payments across all instruments, the green line corresponds to other payments, the red line denotes card payments, and the blue line shows note-based payments.

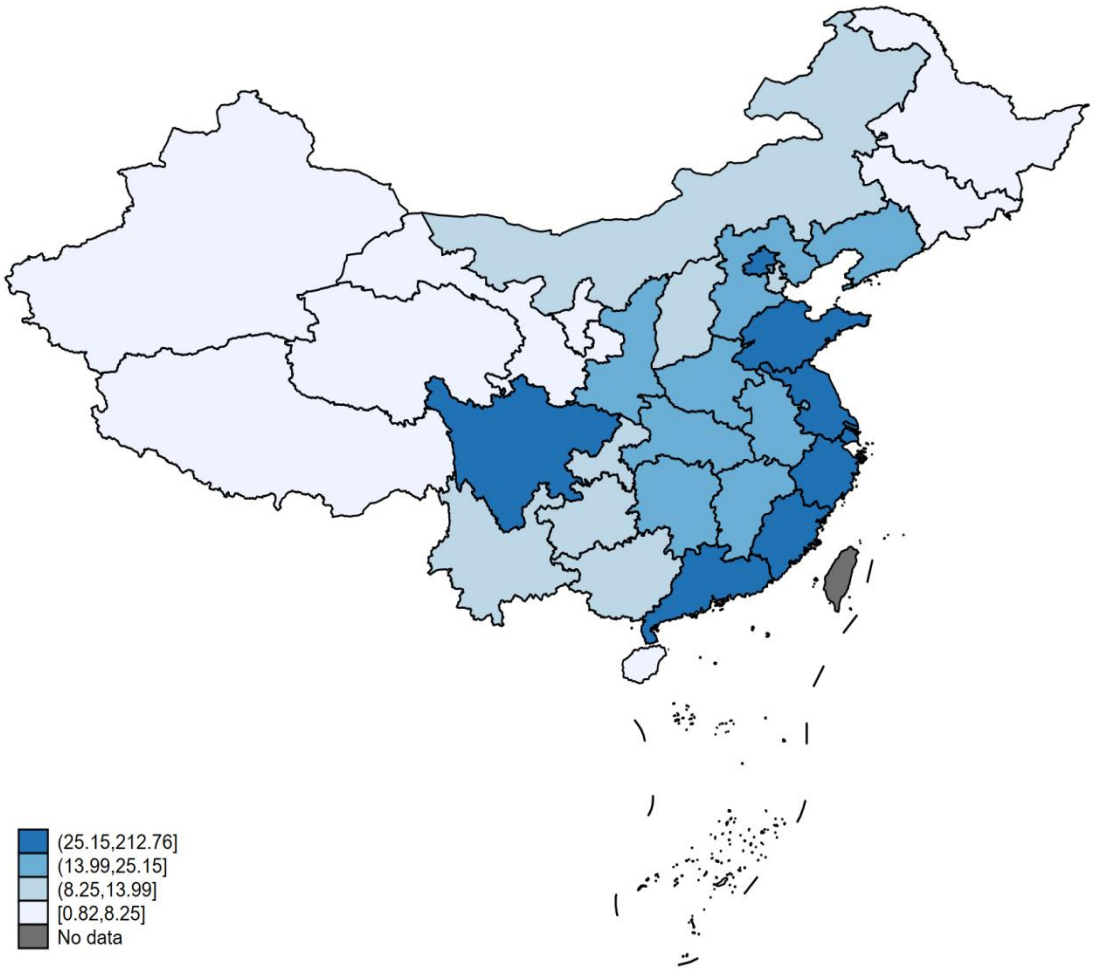


Figure 3. Geographic Distribution of Cashless Payment Amount

This map displays the geographic distribution of total cashless payment amounts across Chinese provinces. Different shades represent varying levels of cashless transaction volumes, with darker colors indicating higher aggregate values. The unit of non-cash payment value is trillion RMB. The figure provides a visual overview of regional differences in cashless payment activity.

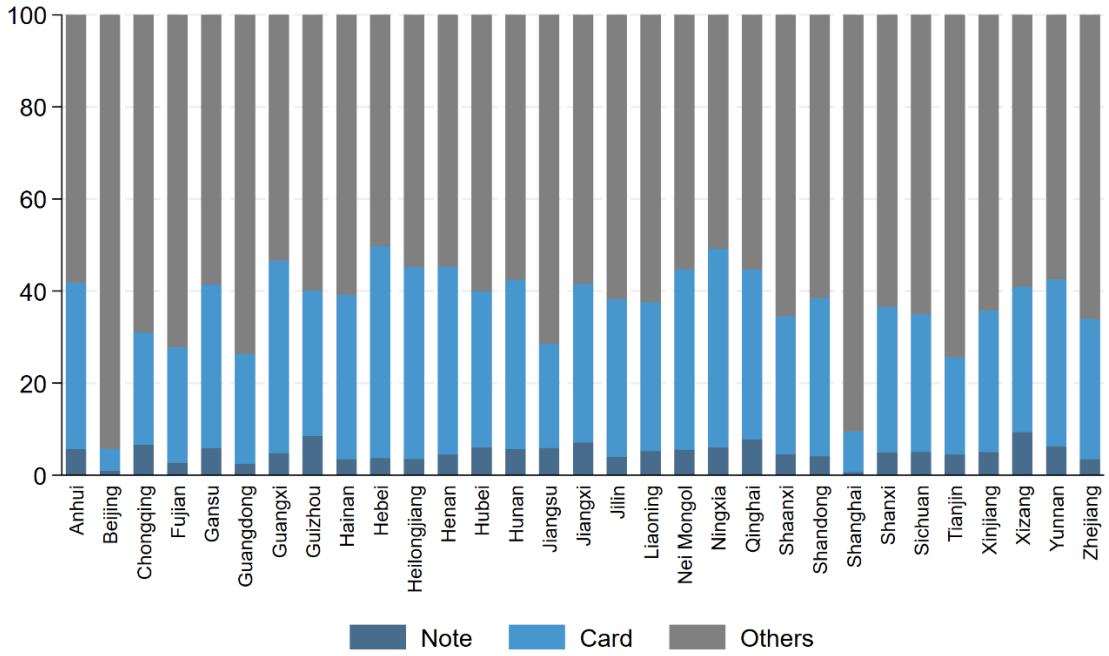


Figure 4. Payment Instrument Proportion by Province

This bar chart illustrates the composition of total cashless payments by instrument type across Chinese provinces. Each bar reflects a province, and the stacked segments show the relative share of each payment method. The figure provides a comparative overview of regional differences in the structure of cashless payment usage on average.

Table 1. Summary Statistics

This table presents summary statistics for the sample. In Panel A, we report growth statistics for cashless payments by amount, number, and average transaction value. Panel B presents a series of macroeconomic indicators included in the estimation. See Appendix Table A1 for the definition of all the variables. Panel C presents pairwise correlations between payment variables and economic indicators. All payment variables are measured at the end of the year-quarter *t*. All continuous variables are winsorized at the 1% level for both tails.

Panel A: Summary Statistics for Growth in Payment Volume, Frequency, and Price by Instrument Type

	N	Mean	STD	Min	Median	Max
Total Growth	651	3.04	10.74	-29.78	3.61	31.90
Note Growth	651	-12.33	12.77	-39.82	-12.54	31.83
Card Growth	651	4.02	11.72	-24.87	2.23	37.64
Others Growth	651	4.63	14.47	-36.54	5.34	47.57
Total Number Growth	651	18.93	16.86	-13.44	15.97	71.04
Note Number Growth	651	-16.81	12.18	-58.54	-15.73	13.95
Card Number Growth	651	19.74	17.56	-13.11	16.73	72.35
Others Number Growth	651	5.13	19.48	-56.19	5.10	71.00
Total Price Growth	651	-11.88	14.11	-50.65	-9.95	18.07
Note Price Growth	651	7.03	17.86	-27.67	4.65	81.72
Card Price Growth	651	-12.38	9.31	-43.29	-10.76	7.70
Others Price Growth	651	2.84	24.43	-48.43	0.80	114.19

Panel B: Macroeconomic, Demographic, and Sectoral Characteristics Across Provinces

	N	Mean	STD	Min	Median	Max
GDP Growth	651	7.39	9.36	-27.76	7.04	36.49
Log (GDP)	651	28.45	0.96	25.77	28.56	30.12
Log (Population)	651	8.14	0.84	5.86	8.28	9.45
Secondary share	631	38.17	9.71	10.55	39.51	65.24
Tertiary share	631	53.69	11.18	30.03	52.41	89.86
Loan/GDP	650	167.72	41.80	93.40	159.87	286.43
Build/GDP	651	22.59	10.21	1.65	22.29	47.12
Income Growth	651	7.24	3.28	-4.38	7.58	15.34
Consumption Growth	651	6.11	8.47	-17.91	6.80	26.77
IV1	620	1.84	2.39	-4.13	1.52	16.42
IV2	620	-5.97	11.25	-60.15	-1.29	8.37
Gini Index	155	43.06	5.02	34.40	42.92	52.18

Panel C: Pairwise Correlation Matrix of Growth, Payment Instruments, and

Macroeconomic Variables

	GG	TG	NG	CG	OG	LG	LP	SS	TS	L/G	B/G	IG
TG	0.29***	1.00										
NG	0.14***	0.47***	1.00									
CG	0.41***	0.47***	0.31***	1.00								
OG	0.21***	0.93***	0.35***	0.18***	1.00							
LG	-0.04	0.19***	0.24***	0.08*	0.14***	1.00						
LP	-0.02	0.14***	0.23***	0.07*	0.10**	0.92***	1.00					
SS	-0.07*	-0.02	0.06	0.01	-0.01	0.14***	0.19***	1.00				
TS	-0.26***	0.07*	0.01	0.05	0.01	0.06	-0.12***	-0.31***	1.00			
L/G	-0.05	-0.03	-0.15***	-0.04	-0.03	-0.51***	-0.63***	-0.24***	0.33***	1.00		
B/G	-0.01	0.12***	0.17***	-0.03	0.12***	0.44***	0.35***	0.13***	0.00	-0.11***	1.00	
IG	0.44***	0.24***	0.26***	0.52***	0.11***	-0.12***	-0.05	0.07*	-0.10***	-0.04	-0.04	1.00
CSG	0.38***	0.22***	0.20***	0.51***	0.07*	0.00	0.05	0.08**	-0.04	-0.11***	0.04	0.69***

Table 2. Determinants of Cashless Payments Growth

This table reports cross-sectional regression results of the determinants of average cashless payment growth for total and each type cashless payment instruments (note, card, others) over the period 2017Q1-2023Q1. The dependent variable is the average year-on-year cashless payment growth rate. We fix all the independent variables at their values at the end of the year 2016. All regressions are estimated using ordinary least squares (OLS) with heteroskedasticity-robust standard errors and t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dept. Var.=	Total Growth	Note Growth	Card Growth	Others Growth
Log(GDP)	-0.233***	-0.113	-0.118*	-0.293***
	(0.036)	(0.092)	(0.065)	(0.046)
Log(Population)	20.541***	11.823	11.328*	24.999***
	(3.023)	(7.963)	(5.854)	(3.833)
Secondary	0.831***	0.616	0.334	1.080***
	(0.184)	(0.383)	(0.205)	(0.234)
Tertiary	0.869***	0.307	0.296	1.117***
	(0.237)	(0.328)	(0.237)	(0.302)
Log(Revenue)	-0.083	-0.134	0.109	-0.156
	(0.113)	(0.181)	(0.125)	(0.135)
Log(Consumption)	0.166***	0.041	0.063	0.217***
	(0.041)	(0.054)	(0.075)	(0.050)
Build/GDP	0.029	0.032	-0.069	0.082
	(0.079)	(0.103)	(0.104)	(0.094)
Loan/GDP	-0.126***	-0.035	-0.041	-0.177***
	(0.034)	(0.038)	(0.027)	(0.043)
Financial Inclusion	0.206*	0.321	0.063	0.247**
	(0.099)	(0.200)	(0.110)	(0.115)
No Education	0.069	-0.024	0.149	0.089
	(0.085)	(0.086)	(0.086)	(0.113)
Observations	31	31	31	31
R-squared	0.571	0.520	0.439	0.545

Table 3. The Effect of Cashless Payment Growth on Provincial GDP Growth

This table reports the OLS baseline regression results. The dependent variable is *GDP Growth*, which is the real GDP growth rate of a province in year-quarter *t*. The independent variable is the year-on-year growth rate of total cashless payment amount and its components (notes, cards, and others). See Appendix Table A1 for the definition of other variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dept. Var.=			GDP Growth (%)			
Total Growth	0.115**	0.086**				
	(0.050)	(0.041)				
Note Growth			0.020			-0.005
			(0.030)			(0.029)
Card Growth				0.191***		0.181***
				(0.045)		(0.043)
Others Growth					0.053**	0.040
					(0.026)	(0.025)
Log(GDP)		-0.867***	-0.880***	-0.839***	-0.873***	-0.837***
		(0.084)	(0.084)	(0.085)	(0.083)	(0.083)
Lagged GDP Growth		-0.130***	-0.129***	-0.129***	-0.130***	-0.129***
		(0.032)	(0.032)	(0.031)	(0.032)	(0.031)
Log(Population)		2.859	1.982	-12.712	7.078	-8.692
		(33.504)	(34.308)	(34.263)	(33.158)	(33.134)
Secondary share		-0.006	-0.005	-0.005	-0.006	-0.005
		(0.060)	(0.061)	(0.058)	(0.060)	(0.056)
Tertiary share		-0.232***	-0.225***	-0.228***	-0.229***	-0.232***
		(0.056)	(0.056)	(0.055)	(0.055)	(0.055)
Loan/GDP		-0.210***	-0.207***	-0.218***	-0.207***	-0.218***
		(0.036)	(0.038)	(0.035)	(0.037)	(0.035)
Build/GDP		-0.261***	-0.274***	-0.258***	-0.265***	-0.250***
		(0.078)	(0.078)	(0.077)	(0.078)	(0.077)
Income Growth		0.442***	0.476***	0.398***	0.461***	0.384***
		(0.130)	(0.128)	(0.126)	(0.129)	(0.127)
Consumption Growth		0.065	0.070	0.038	0.071	0.040
		(0.045)	(0.046)	(0.046)	(0.046)	(0.047)
Observations	651	630	630	630	630	630
Province FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
R-Squared	0.40	0.68	0.68	0.69	0.68	0.70

Table 4. Sectoral Decomposition of GDP Growth and the Role of Cashless Payment Growth

In this table, we report panel regression results for the growth rate of sectoral economic outcomes: primary sector (Panel B), secondary sector (Panel C), and tertiary sector (Panel D). These year-on-year growth rates (in percentages) are measured in year-quarter *t*. The independent variable is the year-on-year growth rate of total cashless payment amount (Panel A) and its components (notes, cards, and others, in Panels B-D). See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust sRobust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Impact of Total Cashless Payment Growth on GDP Growth by Sector			
	(1)	(2)	(3)
Dept. Var.=	Primary GDP Growth (%)	Secondary GDP Growth (%)	Tertiary GDP Growth (%)
Total Growth	0.081	0.170*	0.129**
	(0.069)	(0.093)	(0.062)
Observations	617	617	617
Controls	YES	YES	YES
Province FE	YES	YES	YES
Quarter FE	YES	YES	YES
R-Squared	0.27	0.41	0.39

Panel B: Effects of Payment Instruments on Primary Sector GDP Growth				
	(1)	(2)	(3)	(4)
Dept. Var.=	Primary GDP Growth (%)			
Note Growth	0.126**			0.111**
	(0.054)			(0.055)
Card Growth		0.151		0.122
		(0.092)		(0.094)
Others Growth			0.047	0.017
			(0.053)	(0.054)
Observations	617	617	617	617
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-Squared	0.27	0.27	0.27	0.28

Panel C: Effects of Payment Instruments on Secondary Sector GDP Growth				
	(1)	(2)	(3)	(4)
Dept. Var.=	Secondary GDP Growth (%)			
Note Growth	-0.027			-0.071
	(0.066)			(0.063)

Card Growth		0.243***		0.230**
		(0.090)		(0.091)
Others Growth			0.110*	0.106*
			(0.064)	(0.063)
Observations	617	617	617	617
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-Squared	0.41	0.42	0.41	0.42

Panel D: Effects of Payment Instruments on Tertiary Sector GDP Growth

	(1)	(2)	(3)	(4)
Dept. Var.=	Tertiary GDP Growth (%)			
Note Growth	0.088			0.069
	(0.058)			(0.060)
Card Growth		0.163**		0.139*
		(0.073)		(0.072)
Others Growth			0.057	0.033
			(0.042)	(0.043)
Observations	617	617	617	617
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-Squared	0.39	0.39	0.38	0.39

Table 5. The Impact of Cashless Payment Growth on Provincial GDP Growth: Instrumental Variable Estimation

In this table, we present the results of two-stage instrumental variable (IV) regressions. The two IV variables we use to fix the endogeneity issue include IV1 and IV2. For column (1) and (2), we define the first instrument, IV1, as the interaction terms between the reciprocal of the average number of NGOs per 10,000 people at the provincial level over the period 2000-2016 and the lagged year-on-year growth rate of total cashless payments which varies over time. For columns (3) and (4), we define the second instrument, IV2, as the negative interaction term between the provincial terrain ruggedness and the lagged year-on-year growth rate of total cashless payments. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. For OLS coefficient and LM test, ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. For the F test, ***, greater than 10% Stock-Yogo weak ID test critical value (16.38), ** for 15% critical value (8.96), * for 20% critical value (6.66).

	(1)	(2)	(3)	(4)	(5)	(6)
	1st	2nd	1st	2nd	1st	2nd
Dept. Var.= (%)	Total Growth	GDP Growth	Total Growth	GDP Growth	Total Growth	GDP Growth
IV1	-1.799***				-1.470***	
	(0.407)				(0.420)	
IV2			0.249***		0.209***	
			(0.053)		(0.052)	
Total Growth		0.387*		0.474***		0.434***
		(0.199)		(0.179)		(0.156)
Observations	630	630	630	630	630	630
R-squared	0.51	0.46	0.50	-0.11	0.52	0.36
Controls	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
KP LM test		16.94***		22.31***		29.55***
KP F test		19.53***		22.31***		14.73***

Table 6. Heterogeneity Test: Based on Financial Infrastructure

This table shows the regression results by splitting the sample based on two proxies for financial infrastructure: the degree of financial marketization index (*Low FMI* vs. *High FMI*, Panel A) and the geographic region of the province (*East* vs. *Middle & West*, Panel B). The dependent variable is *GDP Growth*, which is the real GDP growth rate of a province in year-quarter *t*. The difference column denotes the coefficient and standard errors for the difference in estimates between the two subsamples. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses and p values for each difference are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Two Groups by Financial Marketization Index			
By FMI Value:	Low FMI	High FMI	Difference
Total Growth	0.171***	-0.0450	0.216**
	(0.048)	(0.059)	[.011]
Card Growth	0.238***	0.097*	0.141*
	(0.07)	(0.058)	[.078]
Note Growth	0.0480	0.0160	0.0320
	(0.037)	(0.037)	[.328]
Others Growth	0.096***	-0.0310	0.127**
	(0.031)	(0.036)	[.016]
Panel B: Two Groups by Geographic Distribution in China			
By Provincial Location:	Middle & West	East	Difference
Total Growth	0.142***	-0.099*	0.241***
	(0.045)	(0.056)	[.003]
Card Growth	0.174**	0.115**	0.059
	(0.069)	(0.049)	[.29]
Note Growth	0.043	-0.053	0.096*
	(0.032)	(0.05)	[.086]
Others Growth	0.074***	-0.067	0.141***
	(0.028)	(0.043)	[.004]

Table 7. Payment Efficiency Channel: Transaction Volume Per Capita

This table examines whether transaction volume per capita is associated with higher cashless payment growth. The dependent variable is transaction volume per capita for the total and each type of cashless payment instruments. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Transaction Per Capita			
	(1)	(2)	(3)	(4)
	Total	Note	Card	Others
Total Growth	0.160***			
	(0.051)			
Note Growth		-0.000		
		(0.000)		
Card Growth			0.423**	
			(0.171)	
Others Growth				0.001
				(0.001)
Observations	630	630	630	630
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-squared	0.90	0.89	0.90	0.94

Table 8. Financial Inclusion Channel: Interaction with Rural Population Share

This table examines whether the growth effects of cashless payments are stronger in provinces with higher proportion of rural population. The dependent variable is GDP Growth, which is the real GDP growth rate of a province in year-quarter t. The key independent variables are the growth rates of total, note, card, and other cashless payments, respectively, and their interactions with rural population share of the province (*Rural*). See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) GDP Growth	(2) GDP Growth	(3) GDP Growth	(4) GDP Growth
Total Growth	-0.162*			
	(0.096)			
Total Growth * Rural	0.571**			
	(0.222)			
Note Growth		-0.221*		
		(0.114)		
Note Growth * Rural		0.558**		
		(0.262)		
Card Growth			0.134*	
			(0.079)	
Card Growth * Rural			0.135	
			(0.184)	
Others Growth				-0.105
				(0.083)
Others Growth * Rural				0.349*
				(0.191)
Observations	630	630	630	630
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-squared	0.69	0.69	0.70	0.69

Table 9. Financial Inclusion Channel: Interaction with Uneducated Population Share

This table examines whether the growth effects of cashless payments are stronger in provinces with higher proportion of population with no formal education. The dependent variable is GDP Growth, which is the real GDP growth rate of a province in year-quarter t. The key independent variables are the growth rates of total, note, card, and other cashless payments, respectively, and their interactions with uneducated population share of the province (*Noedu*). See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) GDP Growth	(2) GDP Growth	(3) GDP Growth	(4) GDP Growth
Total Growth	-0.026			
	(0.044)			
Total Growth * Noedu	0.014***			
	(0.003)			
Note Growth		-0.048		
		(0.047)		
Note Growth * Noedu		0.010*		
		(0.006)		
Card Growth			0.102**	
			(0.050)	
Card Growth * Noedu			0.011***	
			(0.003)	
Others Growth				-0.030
				(0.030)
Others Growth * Noedu				0.010***
				(0.003)
Observations	630	630	630	630
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-squared	0.70	0.69	0.70	0.69

Table 10. Income Inequality as a Consequence of Financial Inclusion Channel

In this table, we report pooled panel regression results for the potential channel of income inequality. The dependent variable is the *Gini index*, which measures the degree of income inequality among residents in each province in year-quarter *t*. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dept. Var.=	Gini Index			
Total Growth	-0.127**			
	(0.050)			
Note Growth		-0.053		
		(0.041)		
Card Growth			-0.087	
			(0.067)	
Others Growth				-0.062*
				(0.035)
Observations	155	155	155	155
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-Squared	0.57	0.56	0.56	0.56

Appendix A1. Variable Description

Variable Name	Description
GDP Growth	Year-on-year percentage growth rate of provincial real GDP
Total Growth	Year-on-year growth rate of total cashless payment amount
Note Growth	Year-on-year growth rate of note-based payment amount
Card Growth	Year-on-year growth rate of card-based payment amount
Others Growth	Year-on-year growth rate of other cashless payment instruments
Total Number Growth	Year-on-year growth rate of the total number of cashless payment transactions
Note Number Growth	Year-on-year growth rate of the number of note-based transactions
Card Number Growth	Year-on-year growth rate of the number of card transactions
Others Number Growth	Year-on-year growth rate of the number of other electronic transactions
Total Price Growth	Year-on-year growth rate of average cashless transaction value (amount/number)
Note Price Growth	Year-on-year growth rate of average note-based transaction value
Card Price Growth	Year-on-year growth rate of average card-based transaction value
Others Price Growth	Year-on-year growth rate of the average value for other electronic payments
If GDP Growth > Median Value	Binary indicator equal to 1 if provincial GDP growth > median in the same quarter
Log (GDP)	Natural logarithm of the four-quarter rolling sum of real GDP, multiplied by 100
Log (Population)	Natural logarithm of provincial population
Secondary Share	Share of GDP from the secondary (industrial) sector (%)
Tertiary Share	Share of GDP from the tertiary (services) sector (%)
Build/GDP	Ratio of infrastructure investment to GDP (%)
Income Growth	Year-on-year growth rate of per capita disposable income (%)
Consumption Growth	Year-on-year percentage growth rate of per capita household consumption
Loan-to-GDP Ratio	Ratio of total outstanding bank loans to provincial GDP (%)
(Low/High) FMI	Based on the low/high Financial Marketization Index from Wang et al. (2017)
IV1	The interaction terms between the reciprocal of the average number of NGOs per 10,000 people at the provincial level over the period 2000-2016 and the lagged YoY growth rate of total cashless payments
IV2	The negative interaction term between the provincial terrain ruggedness and the lagged YoY growth rate of total cashless payments
Gini Index	The extent to which the distribution of income among residents within a province deviates from a perfectly equal distribution. It ranges from 0 (perfect equality) to 100 (perfect inequality)

Appendix Table A2. Robustness Test: If GDP Growth > Median Value

This table reports the panel regression robustness test. The dependent variable is *If GDP Growth > Median Value*, which is the binary indicator equal to 1 if provincial GDP growth > median in the same year-quarter *t*. The independent variable is the year-on-year growth rate of total cashless payment amount and its components (notes, cards, and others). See Appendix Table A1 for the definition of other variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dept. Var.=	If GDP Growth > Median Value			
Total Growth	0.018***			
	(0.005)			
Note Growth		0.012***		
		(0.004)		
Card Growth			0.026***	
			(0.006)	
Others Growth				0.010***
				(0.003)
Observations	630	630	630	630
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-Squared	0.08	0.08	0.08	0.08

Appendix Table A3. Decomposing the Effects of Cashless Payment Growth on GDP: Quantity versus Price Channels

In this table, we decompose the independent variable (i.e., cashless payment growth) into transaction number and price. These year-on-year growth rates (in percentages) on total payment and its components are still measured in year-quarter *t*. The dependent variable is *GDP Growth*, which is the real GDP growth rate of a province in year-quarter *t*. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Dept. Var.=	GDP Growth (%)				
Total Number Growth	0.100**				
	(0.049)				
Total Price Growth	0.084*				
	(0.047)				
Note Number Growth		0.030			-0.019
		(0.038)			(0.038)
Note Price Growth		0.000			-0.009
		(0.025)			(0.025)
Card Number Growth			0.152***		0.161***
			(0.049)		(0.050)
Card Price Growth			0.240***		0.241***
			(0.056)		(0.057)
Others Number Growth				0.040	0.010
				(0.028)	(0.028)
Others Price Growth				0.037	0.025
				(0.024)	(0.025)
Observations	630	630	630	630	630
Controls	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES
R-Squared	0.68	0.68	0.69	0.68	0.70

Appendix Table A4. Payment Efficiency Channel: Interaction with Bank Branch Numbers

This table examines whether the growth effects of cashless payments are stronger in provinces with weaker financial infrastructure. The dependent variable is GDP Growth, which is the real GDP growth rate of a province in year-quarter t. The key independent variables are the growth rates of total, note, card, and other cashless payments, respectively, and their interactions with the logarithm of bank branches per capita in 2016 ($Bank$), which proxies for the degree of traditional banking access. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
	GDP Growth	GDP Growth	GDP Growth	GDP Growth
Total Growth	0.330			
	(0.237)			
Total Growth * Bank	-0.042			
	(0.038)			
Note Growth		0.317		
		(0.211)		
Note Growth * Bank		-0.051		
		(0.034)		
Card Growth			0.542***	
			(0.192)	
Card Growth * Bank			-0.060**	
			(0.030)	
Others Growth				0.181
				(0.196)
Others Growth * Bank				-0.022
				(0.032)
Observations	630	630	630	630
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
R-squared	0.69	0.68	0.70	0.68

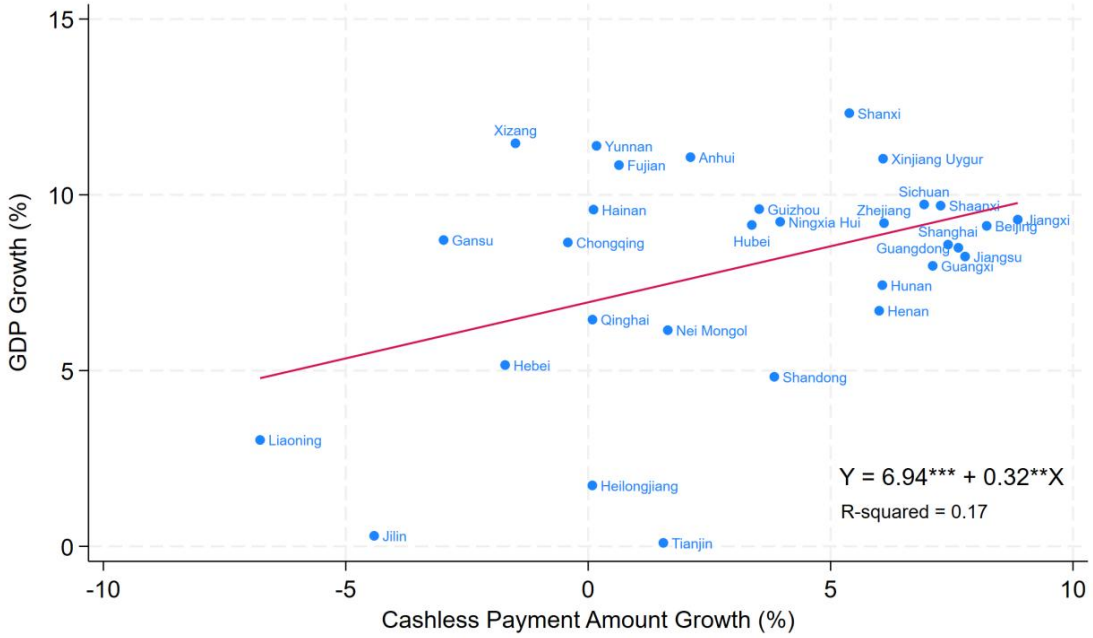
Appendix Table A5. Financial Inclusion Channel: Subsample Analysis Based on Financial Inclusion Index

This table shows the regression results by splitting the sample based on pre-determined Financial Inclusion Index. The dependent variable is *GDP Growth*, which is the real GDP growth rate of a province in year-quarter *t*. The difference column denotes the coefficient and t-statistic for the difference in estimates between the two subsamples. See Appendix Table A1 for the list of control variables. All continuous variables are winsorized at the 1% level for both tails. Robust standard errors are reported in parentheses and p values for each difference are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

By FI:	Low FI	High FI	Difference
Total Growth	0.161***	-0.0510	0.212**
	(0.05)	(0.054)	[.011]
Card Growth	0.222***	0.146***	0.0760
	(0.066)	(0.051)	[.234]
Note Growth	0.063*	-0.0420	0.106**
	(0.038)	(0.039)	[.049]
Others Growth	0.072**	-0.0170	0.089*
	(0.03)	(0.037)	[.066]

Appendix Figure B1. Cashless Payment Growth and Provincial GDP Growth

This figure presents a scatter plot of provincial GDP growth against cashless payment growth, with each dot representing a province. The fitted regression line illustrates the linear relationship between the two variables. The chart provides a visual depiction of how variations in cashless payment expansion are associated with differences in economic performance across regions.



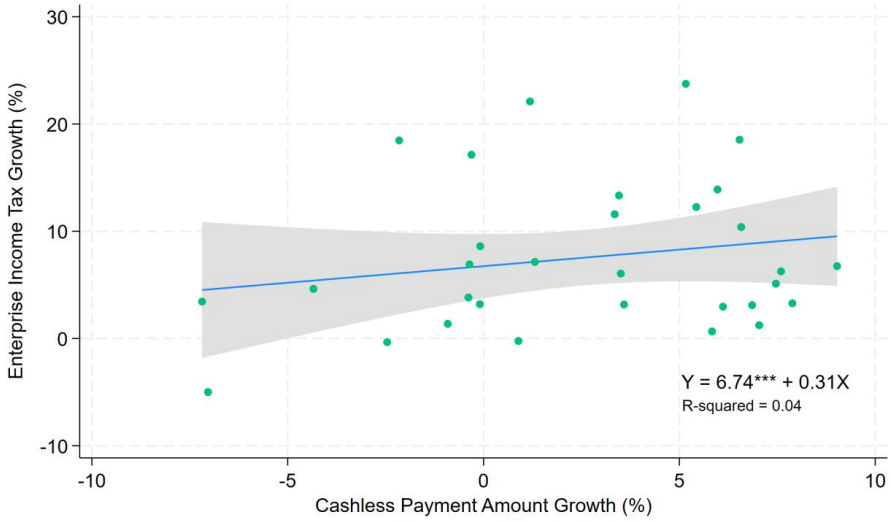
Appendix Figure B2. Further Test: Cross-sectional Evidence on Other Economic Outcomes

This series of figures presents present cross-sectional regression results examining the association between overall cashless payment growth and five provincial-level outcome variables, averaged over the period 2018–2022. The dependent variables are: tax revenue growth (Panel A), enterprise income tax growth (Panel B), individual income tax growth (Panel C), new firm entry (Panel D) measured as the logarithm of the number of newly registered firms, and fixed asset investment growth (excluding households, Panel E). In each case, the horizontal axis represents the average annual growth rate of total cashless payment value during 2018-2022, while the vertical axis corresponds to the respective outcome variable's growth rate.

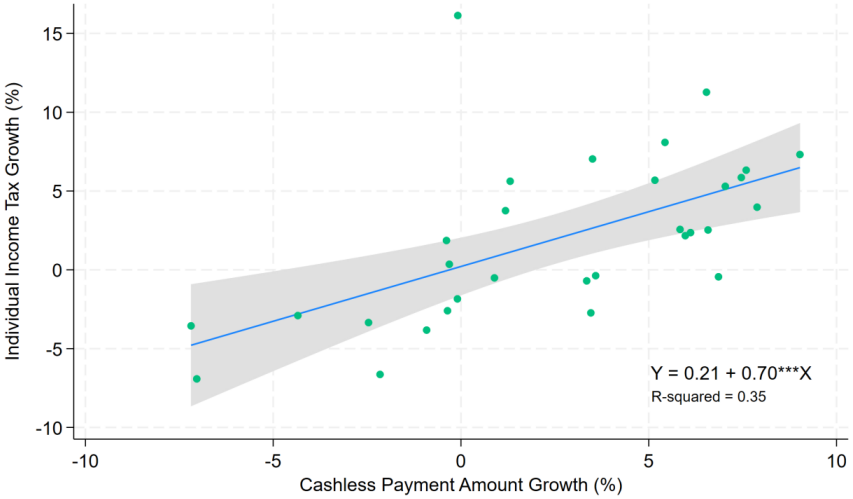
Panel A: Impact on Tax Revenue Growth



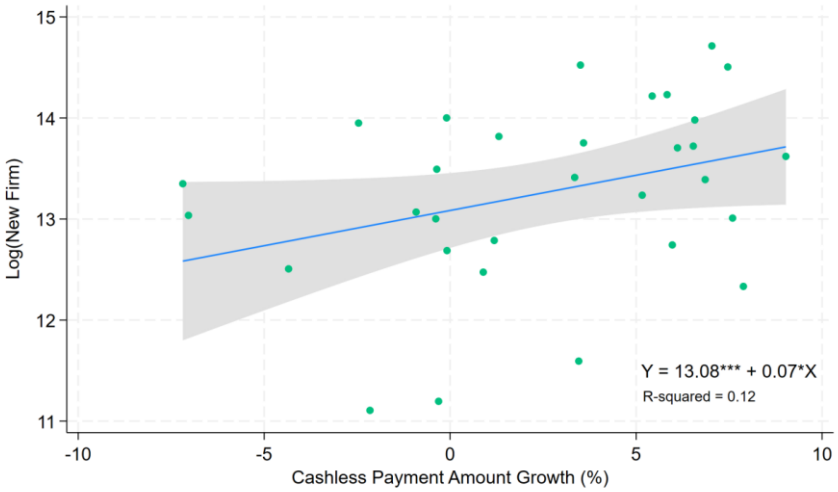
Panel B: Impact on Enterprise Income Tax Growth



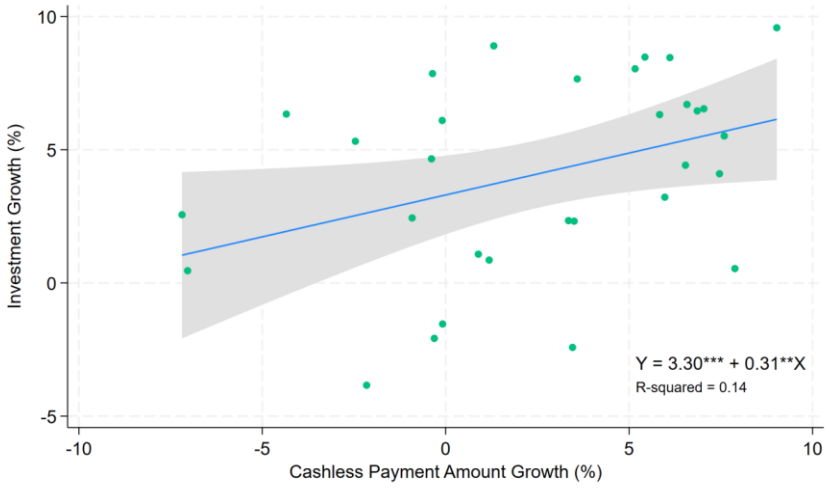
Panel C: Impact on Individual Income Tax Growth



Panel D: Impact on New Firm Entry



Panel E: Impact on Fixed Asset Investment Growth



Appendix C. Model Setup

We develop a simplified model of technological growth to characterize the impact of cashless payment expansion on economic growth. The model assumes that economic output is determined by labor input and the level of technology. The production function is specified as follows:

$$Y_t = A_t \Phi(C_t) L_t \quad (1)$$

where, Y_t denotes total economic output (GDP); L_t denotes labor input, which grows exogenously at rate n, i.e. $\dot{L_t}/L_t = n$; A_t represents the level of conventional technology, growing at rate g_A, i.e. $\dot{A}_t/A_t = g_A$; C_t denotes the level of non-cash payments, growing at rate g_C, i.e. $\dot{C}_t/C_t = g_C$; $\Phi(C_t)$ captures the contribution of the payment system to economic efficiency, specified as:

$$\Phi(C_t) = C_t^{\theta}$$

where $\theta > 0$ is the payment efficiency elasticity parameter.

Taking the logarithm of Equation (1) and differentiating with respect to time yields:

$$\frac{\dot{Y_t}}{Y_t} = \frac{\dot{A_t}}{A_t} + \theta \frac{\dot{C_t}}{C_t} + \frac{\dot{L_t}}{L_t} \quad (2)$$

Substituting the exogenous growth rates gives:

$$g_Y = g_A + \theta g_C + n \quad (3)$$

g_Y is the output growth rate, g_A is the contribution from conventional technological progress, θg_C is the contribution from the expansion of the payment system, n is the contribution from the growth in labor supply.

Then we can get:

$$\frac{\partial g_Y}{\partial g_C} = \theta > 0 \quad (4)$$

This implies that a higher growth rate of non-cash payments leads to a higher economic growth rate. The strength of this effect is determined by the payment efficiency elasticity θ.