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Payment systems, inside money and financial intermediation
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Payment systems, inside money and financial intermediation

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Abstract

We assess the impact of introducing an efficient payment system on financial intermediation. Two channels are investigated. Innovations in wholesale payments technology enhance the security and speed of inside money as a payment medium for customers and therefore affect the split between holdings of cash (outside money) and holdings of deposits (inside money). Second, innovations in wholesale payments technology help establish well-functioning interbank markets for end-of-day funds. This reduces the need for banks to hold excess reserves and thus helps credit creation. We examine these links empirically using payment systems reforms in Eastern European countries as our laboratory. We find evidence that reforms led to a 'crowding in' of cash in favour of demand deposits and that this in turn enabled a prolonged credit expansion in our sample countries. By contrast, while payment system innovations also led to a reduction in excess reserves in some countries, we do not find this effect was causal for the credit boom observed in these countries.

Key words: Payment system reforms, credit accelerations, liquidity preference shocks.

JEL classification: G2, G3.

Contents

Summary

Reforms to improve the efficiency of interbank payment systems have the potential to improve welfare by increasing the demand for inside money (demand deposits created 'inside' the banking system) and reducing the need for outside money (currency and reserves, created by the central bank and therefore 'outside' the banking system). This is because inside money can be put to productive use: banks use deposits to finance lending to the corporate sector. An economy which increases its reliance on inside money relative to outside money may therefore be able to support a higher level of capital and increased growth as that capital is accumulated.

In this paper, we study the effects of payment systems reform, using as a laboratory the transition from paper-based to modern, automated payment systems in Eastern European countries during the period 1995 to 2005. After 1989, these countries undertook major reforms of their financial and banking systems. As part of that effort they introduced modern, secure, automated interbank payment systems. These reforms were introduced to improve the reliability and security and to increase the efficiency of accounts-based payments. At the same time there have been sizable shifts in the amount of funds intermediated by the banking system. Indeed, many commentators have referred to a credit boom in a number of our sample countries. This paper investigates whether payment system reform and credit creation are causally linked. We also study the channels that might effect such a link.

Two channels are investigated. First, innovations in payments technology enhance the speed and security of inside money as a payment medium for customers and therefore affect the split between holdings of cash (outside money) and holdings of deposits (inside money). Second, innovations in payment systems help establish well-functioning interbank markets for end-of-day funds. This reduces the need for banks to hold excess reserves (outside money) to self-insure against end-of-day outflows and thus helps credit creation.

We find that upon the introduction of efficient payment systems there is a marked increase in the trend growth of financial intermediation. This finding exploits differences in the timing of reform across our sample countries, and it is robust to the inclusion of control variables that take account of macroeconomic determinants of credit growth, such as general economic development and the extent of foreign capital inflows, as well as other dimensions of structural change in our sample,

such as variation in government ownership of banking assets.

Further investigation suggests that the trend increase in credit supplied to the private sector is associated with a trend decrease in the use of currency, relative to demand deposits. By contrast, the evidence in favour of a reduction in banks' holding of excess reserves is less strong.

To establish whether any of these two channels might have caused the observed increase in the trend growth of credit around payment reform, we investigate whether there is more generally a positive response of credit to either a shock to the demand for deposit (relative to currency) or the ratio of reserves to deposits. Here we find a corroborating, more general relationship between credit and deposits, but not between credit and reserves. This suggests that while a shift away from cash and towards demand deposits around the reform dates can be argued plausibly to have caused an increase in credit, a shift away from reserves cannot.

Last, while our main results rely on a reform variable that is 'zero-one' we also employ alternative measures of payments systems development, such as the number of credit transfers effected across the payment system. These alternatives provide a continuous and more direct measure of the system's use. Our empirical tests using these alternatives confirm that payment system development is an important contributing factor in accounting for the observed increases in credit creation in some of our sample countries.

'We'd always thought that if you wanted to cripple the US economy, you'd take out the payment systems. Banks would be forced to fall back on inefficient physical transfers of money. Businesses would resort to barter and IOUs; the level of economic activity across the country could drop like a rock.'

Alan Greenspan, Chairman of the Board of Governors of the US Federal Reserve System, 1987-2006.

1 Introduction

Payment systems[1] are the means by which inside money is transferred between banks. Reforms to improve the efficiency of these systems have the potential to improve welfare by increasing the demand for inside money and reducing the need for outside money. The reason is that banks use inside money (deposits) to finance lending to the corporate sector. An economy which increases its reliance on inside money relative to outside money may therefore be able to support a higher level of capital and increased growth as that capital is accumulated.[2] Indeed, the extant literature has found a robust relationship between financial depth, as measured by the amount of credit extended by the banking system and the subsequent rate of growth of the economy as a whole.[3]

Historically, banks have played a central role both in facilitating payments and in the creation of credit. But most theories of banking ignore the interplay between the two. These theories emphasise frictions such as asymmetric information on borrowers and incomplete markets more generally as important in understanding intermediation. In an influential study, Diamond (1984) argued that intermediaries overcome asymmetric information problems by acting as 'delegated monitors'. Another strand of the literature, starting with Diamond and Dybvig (1983), emphasises the role of banks in insuring liquidity needs of customers while at the same time investing in longer-term assets. However in this model and much of the subsequent literature, both a bank's assets and liabilities are real and there is no separate role for outside money. Only very recently have economists started to provide theories of intermediation where monetary

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[1] The term payment system refers to the instruments, organisations, operating procedures, and information and communication systems used to initiate and transmit payment information from payer to payee and to settle payments (BIS (2001), *Core Principles for Systematically Important Payment Systems*, Committee on Payment and Settlement Systems, January).

[2] In this process the transfers of inside money (deposits) is settled through exchanges of outside money ie the ultimate settlement asset, usually central bank balances.

[3] See King and Levine (1993) for an early contribution to this literature. In this paper we examine in more details the determinants of financial depth, taking its potential to contribute to economic growth as given.

disturbances (shifts in the demand for outside versus inside money) can affect the amount of credit provided by the banking system, Diamond and Rajan (2006).

On the other hand, a large body of empirical literature provides evidence linking monetary disturbances to business cycles. It is usually found that this is stronger for the inside component of the money supply than it is for outside money. In their analysis of the Great Depression, Christiano *et al* (2004) argue that the contraction phase was primarily the consequence of a shock that induced a shift away from privately intermediated liabilities, such as bank deposits, and towards currency. This shock drove households to accumulate currency at the expense of demand deposits that could be used to fund entrepreneurs who own and operate the economy's stock of capital. In the same vein, Rockoff (1993) provides evidence that the Great Depression was the consequence of a drastic deterioration in the acceptance of bank money as payment medium. At the time, it was a chain of bank failures that caused the payment system to collapse. It is thought that confidence in bank money was restored only by structural reforms to address financial risk in the banking system, such as the introduction of federal deposit insurance.

Finally, our paper is related to a small literature that has documented links between deposit-taking and lending. There is evidence to suggest that information obtained through monitoring the cash flow in and out of demand deposits can be used by banks to help make credit decisions, Mester, Nakamura and Renault (2007). Moreover, Berlin and Mester (1999) show that banks that are financed by core (transaction) deposits are able to insulate borrowers from changes in aggregate borrowing costs, because what they pay on core deposits is relatively insensitive to economy-wide fluctuations in the cost of credit. Finally, the literature documents synergies between deposit-taking and loan commitments, and hence lending more generally, Kashyap, Rajan and Stein (2002). When withdrawals of deposits are imperfectly correlated with drawdowns on commitments, both can be offered more cheaply, drawing on a common pool of liquid assets held by the bank.

These papers stop short of drawing out the role an efficient interbank payment systems might play with regard to these mechanisms. But arguably, the efficiency of interbank payment systems may affect all of a) banks' ability to offer transactions services to customers, b) the interest rate banks need to pay on transactions deposits and c) their ability to pool liquidity across banks. A greater efficiency of interbank payment systems is thus likely to affect credit creation.

In this paper we investigate whether or not payment system reform and credit creation are linked. We also study the transmission channels that might effect such a link.

As summarised in Chart 1 two channels are investigated. Innovations in wholesale payments technology enhance the reliability of inside money as a payment medium for customers and therefore affect the split between holdings of cash (outside money) and holdings of deposits (inside money). Second, innovations in wholesale payment systems help establish well-functioning interbank markets for end-of-day funds. This reduces the need for banks to hold excess reserves (outside money) to self-ensure against end-of-day outflows and thus helps credit creation.

To examine these links empirically we use as our laboratory a sample of transition economies over the period 1995-2005. All of our sample countries were part of the Eastern European bloc and all have recently joined the European Union. These countries are at a similar level of economic and financial development: all sample economies have bank-based financial systems and financial markets play only a minor role. Our sample represents a relatively homogenous group of countries also in other respects, eg geographic location and size, see Chart 2.

The empirical analysis exploits the fact that these countries have been implementing large one-time reforms of their payment systems, in order to expedite the processing of payments and reduce the risk and uncertainty associated with non-cash payments. That is, we can observe relatively big changes in payments technology. At the same time the effects of these changes are unlikely to be obscured by differences in habit or culture as regards the use of payment systems.[4] Our sample countries are all moving from a world where cash is by far the dominant means of payment to one where non-cash payments are taking hold gradually.

We assess the response of financial intermediation to payment systems reform using a treatment effect estimator which exploits variations in the timing of reforms across countries. We find that upon the introduction of efficient payment systems there is a marked increase in the trend growth of financial intermediation. This finding is robust to the inclusion of control variables that take account of macroeconomic determinants of credit growth, as well as other dimensions of structural change in our sample, such as variation in foreign ownership of banking assets.

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[4]For example, while in most advanced countries, there has over the past two decades been a gradual demise of checks, this has taken longer in some countries (eg the United States, France) than in others (eg Germany), partly as a result of differences in the degree of payments use being entrenched in habit or culture.

Further, we show that the credit acceleration is larger in countries that have less-developed payment systems at the time of the reforms that took place during our sample period.

Further investigation suggests that the trend increase in credit supplied to the private sector is associated with a trend decrease in the use of currency (outside money), relative to demand deposits (inside money), while the evidence in favour of a reduction in banks' holding of excess reserves (outside money) is less strong. In structural reform regressions we find evidence of a more general and significantly positive relationship between credit supply shocks and liquidity preference shocks away from cash and towards bank deposits. Last, an estimation of the relationship between the level of financial intermediation and direct (continuous) measures of payment systems development, such as the number of credit transfers per inhabitant, confirms the contribution of payment systems reforms to credit creation. Overall, these results suggest that for most countries in our sample, the adoption of automated interbank payment systems was an important precondition for the credit boom documented by Cottarelli *et al* (2003), among others.

The remainder of the paper is organised as follows. Section 2 reviews the process of payment systems modernisation in accession countries in the context of the broader structural changes to their banking systems. Section 3 develops a simple model that highlights the role of payment systems in the credit creation process and formalises the two channels that might effect a link between payments systems innovations and credit. Section 4 elaborates the main empirical strategy and discusses the reduced-form results. Section 5 provides structural estimates of the relationship between liquidity preference shocks and credit supply shocks. Section 6 reports estimates using continuous measures of payment systems development. Section 7 concludes the paper.

2   Payment systems and banking reforms in transition economies

The payment systems of the former Eastern European bloc countries were paper-based settlement systems subject to long transport and processing delays. Long and unpredictable settlement times may be a double source of inefficiency. First, long settlement times result in a dominance of cash as a payment medium since the utility of inside money crucially depends upon the ability of the banking sector to process payments quickly. Second, long and unpredictable settlement times may explain (potentially inefficiently) large holdings of excess reserves by commercial banks in these economies, as a buffer against payments shocks. The practice of central banks in those

countries was to offer an overdraft facility only at a high penalty rate thus making the use of central bank credit highly inflexible with respect to market conditions. In response, commercial banks held large amounts of excess reserves in order to avoid the penalty of overdraft financing (Sundararajan and Sensenbrenner (1994) and Balino, Dhawan and Sundararadjan (1994)).

Against this background, in many economies in transition, significant reforms of clearing and settlement systems were introduced as part of the process of financial sector reform in an effort to improve the reliability and security of payments. Overall, efforts to reform payment systems became most intense starting from the mid-90s, the start of our sample period.

Typically, earlier reforms relied on readily available technologies to speed up transportation of documents, modify accounting practices, standardise operating procedures, introduce and improve dedicated courier services and expedite large-value payments by use of cable and telegraphic networks. In addition, measures were adopted to address financial risk in payment systems, namely (1) exposure limits, (2) collateralisation, (3) loss-sharing arrangements, and (4) shortening of time lags in settlements.

The advanced reforms we focus on comprised the introduction of automated arrangements for interbank transactions that offer finality, a high degree of security, and immediate, same-day, or value-dated settlements.[5] Appendix 1 provides further details on payment system reforms, country by country. Major reforms were dated using information contained in the ECB *Blue Book* on payment systems in accession countries (2002) (available online) as well as national central banks' annual reports. In almost all cases, across the sample period there is a single clearly identifiable date of introduction of a modern automated interbank payment system. In a small number of countries, multiple systems supporting different types of interbank transactions were introduced consecutively. In these cases, we focus on the date the first of these systems is introduced.[6]

While this paper highlights the effects of payment system reform for transition economies, structural changes to the banking system also occurred along other dimensions. Chart 3 provides evidence that privatisation resulted in a reduction of government ownership of banking assets in

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[5]With real-time gross settlement (RTGS), payments are settled one by one and in real time – that is, with virtually no delay. Since payments are not netted out, however, gross settlement systems need larger amounts of intraday liquidity to facilitate prompt settlement of payments.

[6]Our results are not affected materially by changes in the dating convention.

many of the sample countries. Moreover, it shows that the speed of privatisation varies across countries. While the government no longer owned a sizable fraction of banking system assets at or soon after the start of the sample period in Estonia, Latvia and Hungary, a gradual process of privatisation was still ongoing in some other countries during our sample period. Chart 3 also documents a rising proportion of banking system assets that are foreign-owned. Finally, countries have undertaken major reforms to the regulatory and supervisory framework that banks are subject to. Chart 4 charts the path of a banking system reform index constructed by the European Bank for Reconstruction and Development (EBRD). A higher banking reform index indicates that banking laws, regulations and prudential supervision are closer to the Bank of International Settlements (BIS) standards.[7]

In addition to the paths for the share of government ownership, the share of foreign ownership and banking reform, Charts 3 and 4 contain a line corresponding to the date of introduction of a modern interbank payment system. While in principle, other aspects of structural reforms may represent confounding influences for our analysis, Charts 3 and 4 suggest that payment system reforms are not contemporaneous with other structural changes, but that instead there is independent variation in the timing of payment system reforms – potentially reflecting differences in central bank preferences and resources dedicated to payment system reforms – which can be exploited in the regression analysis.

3 Conceptual framework

This section sets out a simple and fairly standard model to clarify how the adoption of well-functioning payment systems may affect the amount of funds intermediated by the banking system.

Following Rockoff (1993), assume people want to keep a fraction of their nominal income in the form of liquidity services. These services are generated by two assets, deposits (*D*) and a safe

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[7]The index takes the following values:

1 Little progress beyond establishment of a two-tier system.

2 Significant liberalisation of interest rates and credit allocation; limited use of directed credit or interest rate ceilings.

3 Substantial progress in establishment of bank solvency and of a framework for prudential supervision and regulation; full interest rate liberalisation with little preferential access to cheap refinancing; significant lending to private enterprises; and significant presence of private banks.

4 Significant movement of banking laws and regulations towards BIS standards; well-functioning banking competition and effective prudential supervision; significant term lending to private enterprises; substantial financial deepening.

4+ Standards and performance norms of advanced industrial economies: full convergence of banking laws and regulations with BIS standards; provision of a full set of competitive banking services.

alternative 'cash' C according to a constant elasticity of substitution production function. Then a modified quantity theory can be written as:

$$\left[(\phi D)^{-\alpha} + C^{-\alpha}\right]^{-1/\alpha} = kY \tag{1}$$

where Y is nominal income and ϕ is an index of the quality of deposits in effecting payments. Assuming people try to maximise utility from holding monetary assets by setting the marginal product of currency equal to the marginal product of deposits, the currency to deposits ratio $\frac{C}{D}$ may be expressed as a linear function of the quality of deposits ϕ.

While currency is held by households and does not (perhaps for lack of monitoring skills) get lent out to private sector borrowers, deposits are intermediated by the banking system. In line with Bernanke and Blinder (1988), we assume that loans are imperfect substitutes for bonds. This is realistic in contexts where a large fraction of firms are unable to borrow directly by issuing securities.

A representative bank's balance sheet is given by:

$$R + L^s = D \tag{2}$$

where R stands for total reserves, D is the level of bank deposits and L^s the supply of loans.

Total reserves R include required reserves and excess reserves R^E. The bank is required to maintain reserves with the central bank in proportion to its deposit base. Let θ denote the reserve requirement rate then

$$R^E = R - \theta D \tag{3}$$

As emphasised earlier, the bank holds excess reserves because customer payments expose it to a liquidity risk. In case of illiquidity, it would have to borrow the missing reserves at a high penalty

rate from the central bank. Alternatively, liquidity risk can be insured in the interbank market. This in turn relies on well-functioning markets for end-of-day funds.

Combining **(2)** and **(3)** the loan supply L^s function reads:

$$L^s = (1 - \theta) D - R^E \tag{4}$$

The introduction of well-functioning payment systems may be thought as a permanent positive shock to ϕ (and hence D) and a permanent negative shock to banks' desired level of excess reserves R^E. From conditions **(1)** and **(4)** one obtains $L^{s\prime}(\phi) > 0$. Moreover, if output in turn is a function of the available supply of credit, there is a positive feedback mechanism that leads in turn to higher equilibrium output and credit.

Another possible channel whereby payments systems innovation affects credit in this set up is given by the comparative static $L^{s\prime}(R^E) < 0$. The reserves channel is active conditional on the central bank not adjusting its supply of reserves systematically to accommodate changes in commercial banks demand.

4 Reduced-form specifications and results

4.1 *Reduced-form model – the effect of payment systems reforms on financial intermediation*

We propose the following reduced-form specification to identify trend changes in the supply of credit around the transition to modern payment systems:

$$FI_{it} = \alpha_{11} + X_{it-2}\alpha_{12} + \alpha_{13} (R_{it}) + \beta_{1i} + t_i + \varepsilon_{1it} \tag{5}$$

where FI_{it} (financial intermediation) stands for the credit over GDP ratio in country i in quarter t. The independent variable of interest is the post-reform trend R_{it} starting at one for the first post-reform quarter which measures the augmentation in credit growth from the country-specific trend t_i. As FI trends upwards over the sample period (for some countries) we model the effect of payment systems reforms as an acceleration in credit growth above country-specific sample trends.

The regression includes country dummies β_{1i} to control for all time-invariant omitted variables. Also included are seasonal dummies and year-fixed effects to control for shocks common to all countries, such as credit accelerations – whatever their cause – that affect the whole region. Standard errors are corrected for clustering of the error terms at the country level, to allow for serial correlation and heteroskedasticity in the error term over time.

X_{it-2} is a vector of observable control variables. The set of controls follows closely the extant literature on the determinants of financial deepening (measured by private credit over GDP). Specifically, it includes those factors that Cottarelli *et al* (2003) (among others) emphasise as the main causes of the credit boom in Eastern Europe; namely fiscal consolidations and structural reforms in the banking sector.

The ratio of total government expenditures over GDP is used to capture the potential for reductions in public spending to crowd-in credit to the private sector. We therefore expect a negative sign on this variable. We also include the level of activity, namely the log real per capita GDP and expect, based on prior evidence, eg Detragiache, Tressel and Gupta (2006), this variable to have a positive effect on financial depth (private credit over GDP).

In addition, we control for the effect of inflation on credit. Following Boyd, Levine and Smith (2001) and Cottarelli *et al* (2003) we allow for this effect to be non-linear, through inclusion of a high-inflation dummy, which takes the value of one when inflation is above a threshold (equal to the 75th percentile), and an interaction term of inflation with the high-inflation dummy. Based on existing evidence, we expect inflation to have a negative effect on credit for inflation rates above the threshold, while for rates of inflation below the threshold, increases in inflation are expected to have no or a small positive effect on credit.

We also include a number of variables that capture structural changes to the banking sector. First we include the share of banking assets owned by the government and the share of banking system assets that are foreign-owned. While it has been suggested that privatisation and a high share of foreign assets might have contributed to a relatively rapid expansion in credit extended by the banking sector in some transition economies, Cottarelli *et al* (2003), neither theory nor more recent existing evidence on the effect of these variables on financial depth is clear-cut. Cross-sectional studies do not typically find a robust correlation between government ownership and credit extended by the banking system, eg Detragiache *et al* (2006). On the other hand, a

recent study on the French banking reforms in 1985, that involved a retreat by the French Treasury from close control of the banking system as well as privatisation of state-owned banks, finds that bank credit contracted in the wake of these reforms, Bertrand, Schoar and Thesmar (2007). Further tests provided in this study are consistent with the idea that state ownership implies a soft budget constraint that can give incentives for banks to lend even to unprofitable businesses.

A large empirical literature on the effects of foreign ownership on credit extended by the banking sector is surveyed in Detragiache *et al* (2006). Again this literature has not reached firm conclusions. On the one hand foreign ownership leads to an import of human capital and expertise in screening borrowers. On the other hand, foreign banks may tend not to take full account of soft (and local) information, resulting in greater rationing of credit. Detragiache *et al* (2006) model this trade-off. Their model implies that foreign ownership should be associated with a reduction in credit in poor countries, while on balance no effect is predicted for high-income countries. In cross-sectional regressions of bank credit on the share of foreign ownership they find evidence that confirms both of these predictions. In other words, foreign ownership leads to a reduction in credit for poor countries, but has no discernible effect for high-income countries.

In addition to the share of government and foreign ownership we include the EBRD banking reform index. To the best of our knowledge, this comprehensive index of the regulatory and supervisory framework has not been used in empirical research before, but related evidence in Barth, Caprio and Levine (2006) suggests that official supervisory power correlates negatively with credit to GDP. Since structural characteristics of the banking system, captured by the EBRD index, are separately accounted for through use of government ownership variables, we expect a negative coefficient on the EBRD banking reform index.

According to Cottarelli *et al* (2003) capital inflows had not been a major determinant of the credit boom in Eastern European countries up to 2002. Since then however, some of these countries may have experienced an increase in capital inflows which could have come to fuel the credit boom in some of our sample countries. To account for capital inflows received by the domestic banking system we include the foreign exchange reserves held at the central bank, scaled by GDP.[8] Last, banking crises are accounted for, by including a dummy that takes value one in crisis

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[8]We also experimented with a broader measure of inflows including foreign direct investment, portfolio flows and debt liabilities. This

inception years and the following two years,[9] with a negative effect expected on credit to GDP.

The analysis uses quarterly data covering the ten countries listed in Appendix 1 over the period 1995-2005; as set out above, the sample is chosen such that it comprises all countries that were part of the former Eastern European bloc and that now are members of the European Union.[10] During the sample period, seven of these countries reformed their payment systems, with two countries (Poland and Czech Republic) having completed payment system reforms before the start of the sample period and one country (Romania) embarking on major reforms only at the very end of the sample.[11] These countries are included to achieve greater efficiency in the measurement of the effect of control variables. Appendix 2 contains the list of variables used and the corresponding sources.

Summary statistics for all variables used in our tests are reported in Table A. The descriptive statistics reported in the first panel show an increase in financial intermediation over the sample period accompanied by a decline in the currency over demand deposits ratio and a small increase in the excess reserves over total deposits ratio.[12] The second panel reports a correlation matrix for a number of control variables. The correlation is high among some of these variables. Our approach is therefore to check the robustness of our results to the inclusion of alternative sets of controls.

We go on to investigate the determinants of the trend in financial intermediation by estimating equation **(5)**. The main results are reported in Table B Panel B1. All the independent variables are lagged by two periods[13] (ie half a year) to address possible reverse causality,[14] insofar as the ε_{1it} are independent of each other and across time. The specifications shown include control

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variable tended not to be significant.

[9]Banking crises are identified using the Caprio-Klingebiel (2003) World Bank data set at www1.worldbank.org/finance/html/database_sfd.html. According to this source, banking crises ocourred in the following countries (with crisis inception years in brackets): Bulgaria (1996), Latvia (1995), Poland (1993), Lithuania (1994).

[10]Bulgaria and Romania joined the European Union in 2007. All other sample countries joined in 2004. Slovenia has – in 2007 – also joined the euro.

[11]The series used are not available for a sufficiently long period prior to reform in Poland and the Czech Republic (notably quarterly GDP).

[12]Credit to the private sector includes credit in both domestic and foreign currency. Payments technology may affect the use of domestic currency transactions accounts by residents. The monitoring of these accounts can influence the decision to grant credit, independent of the denomination of the debt. Total credit seems therefore the right dependent variable to use. Moreover, while changes in domestic currency payments technology may at the margin favour domestic credit over foreign currency credit, for lack of data we are unable to explore whether payment system reforms might have brought about changes in the currency composition of the credit extended.

[13]We will later test the robustness of our results to alternative numbers of lags.

[14]In particular, the finance and growth literature suggests that financial development may help to promote economic growth which would mean that GDP per capita may be a function of either the current or past levels of financial development.

variables, in addition to the full set of country-fixed effects, country-specific trends, year effects and seasonal effects. The model has a very good fit with a within R-squared at 0.89. The coefficient on the trend break variable is statistically significant at the 5% level. Its size suggests that the growth in financial intermediation accelerates by around 4 percentage points per annum post transition to modern payment systems, which is an economically sizable effect. Moreover, all control variables have expected signs.

In line with prior evidence we find the effect of inflation to be non-linear, while overall economic activity has a robust positive effect. We also find evidence that fiscal consolidation leads private credit to expand.

Interestingly, the EBRD banking reform index is assigned a negative coefficient, suggesting that better compliance with supervisory standards puts a break on credit creation, as might have been expected.

In line with the result reported in Detragiache *et al* (2006) for high-income countries, we find there to be no significant effect of foreign ownership on credit.[15] However, we find a robustly positive relationship between public ownership and credit, in line with the evidence reported in Bertrand, Schoar and Thesmar (2007) and consistent with the idea that public ownership results in soft budget constraints on banking firms.

Finally, as one would expect there is a positive and significant relationship between capital flows into the banking system (measured by changes in foreign exchange reserves over GDP) and the credit over GDP ratio.

Overall, while macro factors (including inflation, capital inflows, and GDP) are shown to play an important role, this evidence suggests that privatisation and increases in foreign ownership are unlikely to have been an important contributor to increases in credit observed in a number of countries over the sample period. Likewise, the overhaul of the regulatory and supervisory framework appears to have had the effect of slowing rather than accelerating credit growth. Instead, our results single out reform of payment systems as the key ingredient within the overall reform process that led to increases in credit in some of the sample countries.

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[15]The share of foreign ownership remains insignificant when the share of public ownership is omitted from the equation. This implies that the insignificant effect is not accounted for by a multicollinearity problem (high correlation) between these two variables.

In Panel B2 we present variations of the benchmark specification that were conducted to examine the robustness of our findings across subsamples and lag lengths.

First we extend specification **(5)** to a difference-in-difference specification that allows the size of the credit acceleration to be higher for countries that have less-developed payment systems at the time of reforms that took place during our sample period. As described in Appendix 1 the reform process started earlier than 1995 in some countries. For instance, Bulgaria and Estonia had introduced some form of automated system in 1992. Other countries like Latvia and Lithuania experienced a one-time switch from paper-based to automated RTGS systems. We exploit these disparities in our identification of the causal effect of payment systems reform on credit by interacting the reform trend break with indicators of payment systems development in the period preceding the reform in each country. Formally the specification we use reads:

$$FI_{it} = \alpha_{11}' + X_{it-2}\alpha_{12}' + \alpha_{13}'R_{it} + \alpha_{14}R_{it} * I_i + \beta_{1i}' + t_i' + \varepsilon_{1it}' \qquad \textbf{(6)}$$

Following our conceptual framework in Section 3 payment systems development before reform is measured by the pre-reform currency over demand deposits ratio CI_i and the pre-reform excess reserves over total deposits ratio RI_i.

Column (1) shows the results from this augmented specification. In line with our conceptual framework the credit acceleration is larger in countries that report a higher currency ratio and higher excess reserves ratio in the period immediately preceding the introduction of a modern automated payment system.

Column (2) shows a regression where the sample is restricted to those countries that experienced a payment system reform during the sample period (ie excluding Czech Republic, Poland and Romania), with the results virtually unchanged.

While in our preferred specification, control variables are lagged by two quarters (half a year), columns (3) and (4) report models that employ a different lag length (four and zero quarters, respectively) for the controls. In both these specifications, while the R2 remains high and the measured effect on the post reform trend remains significant, some of the coefficients on the control variables lose significance. This suggests that the effects of the control variables are not

immediate but take some time to work themselves through, and that at the same time there is relatively limited autocorrelation in the control variables.

Column (5) reports similar results for the difference-in-difference specification estimated on a sample that excludes non-reform countries. Column (6) reports a control experiment. We assigned the average date of reform to the three countries (Poland, Romania and the Czech Republic) that did not undertake a reform over the sample period and checked whether evidence of a credit acceleration around the average reform time emerges for non-reform countries. The result confirms that the accelerations in financial intermediation in the reform countries do not reflect a global trend in the region.

4.2   Reduced-form model – transmission channels

The conceptual framework developed in Section 3 highlights two channels through which a payment systems reform might affect credit creation. These are: a shift in the desired holdings of cash relative to demand deposits (on the part of customers) and a reduction in the desired holdings of excess reserves relative to total deposits (on the part of banks). In an attempt to determine which, if any of these channels might be related to our finding of an increased growth of credit post reform, we explore whether payment system reforms also induce trend breaks in these series. To this end, specifications analogous to equation **(5)** are estimated as before, including country-fixed effects, year effects and country-specific time trends. Control variables are based on standard forms of the demand for currency and demand for excess reserves, respectively.[16]

$$\frac{\text{Currency}}{\text{Demand Deposits}} = f^C(X^C) + \varepsilon^C \tag{7}$$

$$\frac{\text{Excess Reserves}}{\text{Total Deposits}} = f^R\left(X^R\right) + \varepsilon^R \tag{8}$$

Currency is the money in circulation (domestic currency notes and coins). Total deposits include

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[16]In particular we use specifications similar to Drehmann, Goodhart and Krueger (2002) and Rogoff (1998) for the money demand equation and Agenor, Aizenman and Hoffmaister (2004) for the demand for excess reserves equation.

both demand deposits and term deposits.[17]

As regards the demand for currency, X^C includes variables that capture the opportunity cost – the nominal interest rate – of holding currency and the 'bad behaviour' motives for holding currency. The latter are proxied by the ratio of government taxes over GDP,[18] capturing incentives for the development of black-market activities and tax avoidance. The log real GDP per capita is also included as measuring the transaction motives for holding currency.

As regards the demand for excess reserves, X^R includes variables that control for the opportunity cost of holding excess reserves (namely the nominal interest rate), the reserve requirement ratio and output growth.[19] We also include the foreign reserves over GDP ratio in the excess reserves equation. If the central bank sterilises fully the increase in domestic currency brought about by inflows of foreign currency, commercial banks reserves should be unrelated to variations in the inflow of foreign currency. Otherwise, one might expect to observe an increase in reserves.

We report both fixed effects and seemingly unrelated least squares (SURE) estimates of the two equations **(6)** and **(7)** in Table C. SURE extends ordinary least squares analysis to estimate a system of linear equations with correlated error terms, which gives more efficient point estimates. For both equations we obtain a reasonable overall fit, with the more efficient SURE estimator giving more significant point estimates.

For equation **(6)** we find a statistically significant negative post transition trend break in the currency ratio.[20] The reduction is 1.5 percentage points per quarter ie 6 percentage points per annum, and thus similar in magnitude to the estimated reduced-form effect of payment systems reform on credit. Moreover all control variables have the expected sign and most of them are statistically significant. Plausibly, lower economic development, higher taxes, and lower nominal interest rates increase the use of cash relative to deposits.

For equation **(7)**, we find that excess reserves are negatively related to output growth and,

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[17]Both demand deposits and term deposits may include foreign currency deposits.

[18]This is in practice proxied by government consumption expenditures over GDP because for most countries the tax to GDP ratio is not available at a quarterly frequency for the sample period.

[19]We also used the ratio of demand to saving deposits ratio but did not obtain robust results for the effect of this variable. We therefore dropped it from our analysis.

[20]This estimate may be taken as a lower bound as the introduction of an efficient payment system is expected to trigger a decline in dollarisation.

plausibly, negatively related also with the ratio of required reserves. In addition, the coefficient on foreign exchange reserves over GDP is not significant at conventional levels, indicating that central banks sterilise foreign inflows fully.[21] However no significant trend break is detected upon introduction of an efficient payment system. We hypothesise that the effects could be stronger for those countries where pre-reform reserves holdings are relatively high. Hence, column (3) includes the interaction of the trend break variable with the initial excess reserves ratio. The estimated coefficient indicates a negative trend break for countries starting at a higher level of excess reserves holding.[22]

Overall, this evidence suggests that payment system reforms are associated with a statistically significant and sizable reduction in currency relative to demand deposits. There is also evidence of a reduction in excess reserve holdings, but the evidence is considerably weaker overall.

5 Structural model

To investigate further which of the two channels is likely to have caused the trend increase in financial intermediation post reform, we investigate the structural relationship between all three variables – credit, currency and excess reserves. The idea is as follows: for a trend reduction in the currency ratio to have caused the trend increase in financial intermediation, it needs to be true more generally that liquidity shocks away from currency result in an increase in credit. Likewise, for a reduction in excess reserves to have caused the increase in financial intermediation, it must be true more generally that shifts in the demand for excess reserves are associated with shifts in credit supply. We therefore examine the relationship between shocks to the supply of credit and (innovation-driven) shocks to the demand for outside money (both currency and excess reserves), as follows:

$$\widehat{\varepsilon}^{fi}{}_{it} = \alpha_{51} + \alpha_{52}\widehat{\varepsilon}^{j}_{it} + \beta_{5i} + \gamma_{5t} + \upsilon_{5it} \qquad \textbf{(9)}$$

In this equation, j={r, c} denote reserves and currency respectively, υ_{5it} is an error term and $\{\widehat{\varepsilon}^{fi}, \widehat{\varepsilon}^{r}, \widehat{\varepsilon}^{c}\}$ are the predicted residuals from regressions (9) and (10) estimated by SURE:

$$FI_{it} = \alpha_{31} + X_{it-2}\alpha_{32} + \beta_{3i} + \gamma_{3t} + \varepsilon_{it}^{fi} \tag{10}$$

$$y_{it}^{j} = \alpha_{41} + X_{it}^{j}\alpha_{42} + \beta_{4i} + \gamma_{4t} + \varepsilon_{it}^{j} \tag{11}$$

y is either the excess reserves over total deposits ratio or the currency over demand deposits ratio. Specification **(8)** allows us to explore a relationship between innovation-drive shocks to the demand for outside money, reflected in $\widehat{\varepsilon}^{r}$ and $\widehat{\varepsilon}^{c}$, and unexplained variations in the level of financial intermediation. The fixed-effect estimate of the structural parameter α_{52} is consistent after removing the effects of control variables common to equations **(9)** and **(10)**.

Table D, columns (1) and (2), reports the results of estimating equation **(8)** using a fixed-effects estimator. The point estimates confirm that liquidity preference shocks away from cash and towards bank deposits cause positive credit supply variations that are both statistically and economically significant. By contrast, we do not find a relationship between shocks to the demand for excess reserves and credit. One reason could be that excess reserves are noisy relative to both deposits and credit extended by banks which makes it harder to pick up a relationship empirically. Another reason is that the level of excess reserves plays a minor role in determining banks' lending behaviour.

To account for potential reverse causality between shocks to credit and shocks to currency and reserves, we employ an alternative, instrumental variables (IV) estimator, using lagged innovations as instruments for contemporaneous innovations. Our identification assumption is that while there is a reasonable autocorrelation in $\widehat{\varepsilon}_{it}^{j}$ the effect of $\widehat{\varepsilon}_{it}^{j}$ on $\widehat{\varepsilon}^{fi}{}_{it}$ is immediate to short-lagged. In this case, $\widehat{\varepsilon}_{it-2}^{j}$ and $\widehat{\varepsilon}_{it-3}^{j}$ are valid (excluded) instruments for $\widehat{\varepsilon}_{it}^{j}$. Table D, columns (3) and (4), reports the IV estimates along with weak instrumentation and overidentification tests which confirm the validity of our instruments. We find the effect of shocks to the currency ratio strengthened,[23] while shocks to the reserves ratio have no effect on credit as before.

Overall, the structural estimates confirm that payment systems reforms could plausibly have had a causal effect on credit creation, through increasing the demand for deposits, relative to cash.

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[23] Presumably, measurement error biases ordinary least squares estimates downwards.

However, while we found some reduction in excess reserves in some of our sample countries around the date of payment systems reforms, the structural analysis suggests that this effect may not have been an important causal driver of the effect of payment systems reforms on credit.

These findings may shed light on the ongoing debate on the mechanisms that underlie the 'bank lending channel' of monetary policy. The traditional view is that monetary policy can affect the amount of reserves held by the banking system and that this in turn can affect the supply of credit to the economy (Bernanke and Blinder (1988)). A more recent paper by Diamond and Rajan (2006) argued that this cannot be the mechanism at work when banks in modern monetary economies in fact hold only very small, if any reserves with the central bank. In their model, monetary policy can affect the relative attractiveness of cash versus deposits and in that way changes the amount of lending. Our paper provides fresh evidence in favour of this, alternative view. Even in economies where excess reserves holdings are still relatively sizable (7% in our sample), variations in excess reserves have no discernible effect on the amount of credit intermediated in the economy. And while payment system reform tends to reduce excess reserve holdings, the key benefit for the creation of credit stems from a crowding in of money holdings – in favour of bank deposits – by bank customers.

6   Continuous measures of payment systems development

We further test the robustness of our conclusions by using two alternative continuous measures of payment system development: (1) the number of credit transfers per inhabitant; (2) the number of all non-cash payments per inhabitant (including direct debits and cheques). Yearly data are reported in the ECB *Blue Book* for the period 1996-2001 for all countries in our sample except Bulgaria. Descriptive statistics reported in Table A show a huge variability in the use of non-cash payment instruments across countries which in our sample is unlikely to be attributable fully to variations in levels of economic development or culture. For instance, the number of credit transfers per inhabitant in 1996 is 30 in the Czech Republic and 4 in Hungary.

Because the period covers only the post-reform period for some countries or only the pre-reform period in others, and because the variation in the measures of payment systems development is mostly in the cross-section, we use an ordinary least squares estimator including year-fixed effects but excluding country-fixed effects (ie only cross-country variations within a year are exploited).

Our specification controls for real income per capita and the full set of determinants of financial development (all lagged one year) as listed in Table B. The estimation results reported in Table E confirm our conclusions. An increase in the number of non-cash payments is associated with a statistically significant increase in credit. This effect is again economically significant. A one standard deviation increase in the number of credit transfers per inhabitant is associated with a 6.4 percentage points rise in the annual credit to GDP ratio.

7 Conclusion

Previous studies pointed out fiscal consolidations and structural reforms as drivers of the credit boom observed in Eastern Europe (see eg Cottarelli *et al* (2003)). This paper emphasises that the adoption of well-functioning payment systems were an important precondition for the observed acceleration of credit. Indeed, our results serve to illustrate a simple but fundamental point: the banking system's function as provider of credit to the economy builds on its capacity to offer a reliable payment medium. This means that reforms to improve the efficiency of interbank payment systems have a first-order effect on the amount of credit provided by the banking system. We investigate two channels. First, payment system reform leads to reduction of settlement float and increases the attractiveness of making payments via bank deposits relative to the use of cash (outside money). Second, reforms to interbank payment systems enable banks to economise on their holdings of excess reserves (outside money).

Overall, we find strong evidence that the first of these channels is at work. We find payment systems reforms to be associated with a trend increase in credit. We also find that payment systems reforms decrease the amount of cash used in the economy, relative to bank deposits. Moreover, further evidence suggests that these two findings are unlikely to be coincidental: negative shocks to the currency ratio result more generally in an increase in credit. As regards the reserves channel, we find less compelling evidence. While for some countries, payment systems reform appears to have led to a decrease in excess reserves, we do not find that a decrease in the excess reserves ratio results more generally in an increase in credit.

Chart 1: Transmission mechanisms

```
              ┌─────────────────────┐
              │  Payments Systems   │
              │      Reforms        │
              └─────────────────────┘
                ┌───────────────┴───────────────┐
        ┌───────────────┐               ┌─────────────────────┐
        │ Currency Holding │            │ Excess Reserves Holding │
        └───────────────┘               └─────────────────────┘
                │                               │
        ┌──────────────────────┐        ┌──────────────────────┐
        │ Financial Intermediation │     │ Financial Intermediation │
        └──────────────────────┘        └──────────────────────┘
```
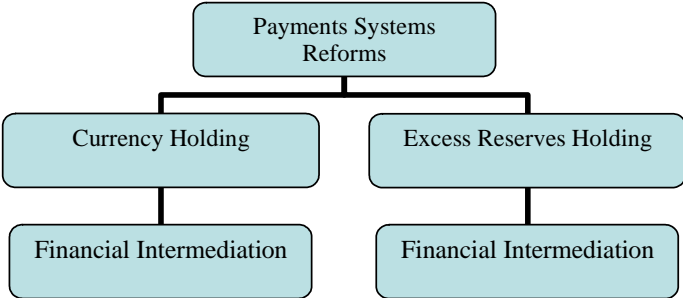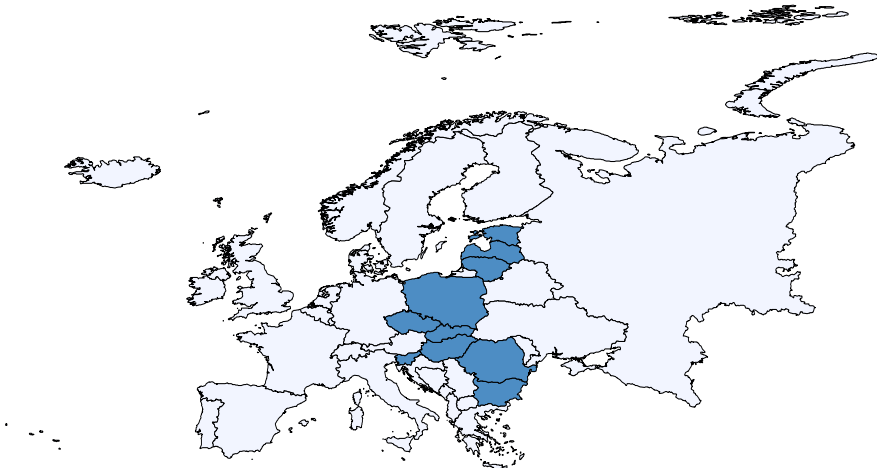
Chart 2: Countries in sample

Chart 3: Public and foreign ownership (share) of banking sector assets
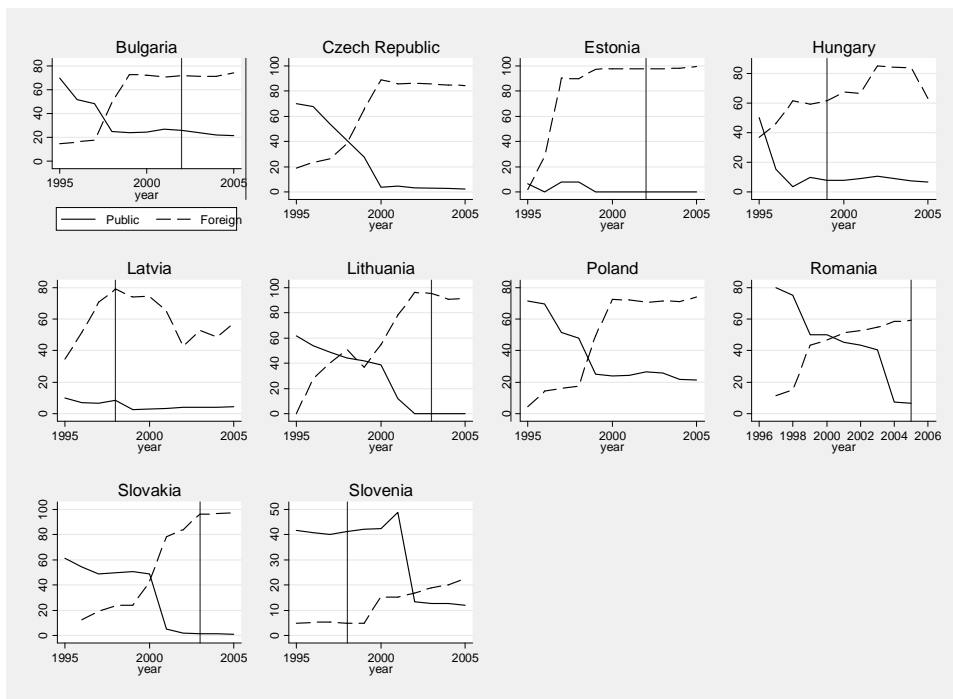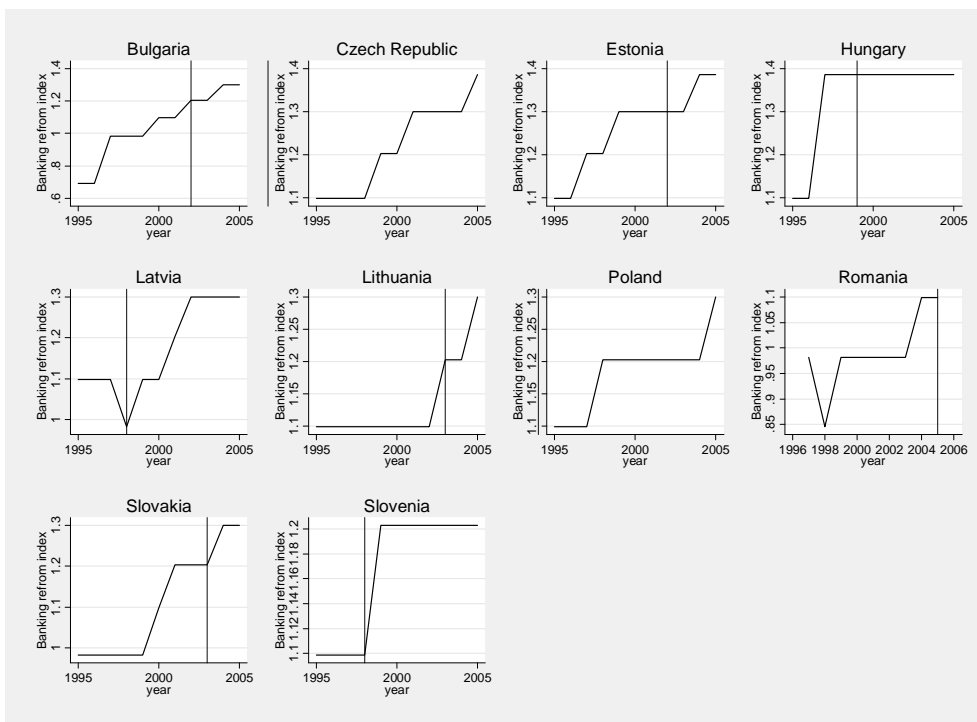

Chart 4: EBRD banking reform index

Table A: Descriptive statistics

Means and standard deviations

	Mean	Standard deviation	Difference 1995-2005		Frequency	Number of observations
			Mean	Std.		
Dependent variables						
Quarterly credit over quarterly GDP	1.099	0.587	0.565	0.894	quarterly	432
Annual credit over annual GDP†	0.264	0.165			yearly	53
Currency over demand deposits	0.744	0.366	-0.376	0.322	quarterly	432
Excess reserves over total deposits	0.07	0.09	0.029	0.058	quarterly	432
Independent variables						
Inflation rate	3.462	19.94	-3.116	3.455	quarterly	424
Government consumption expenditure/GDP	0.184	0.041	-0.025	0.042	quarterly	432
Banking reform index	1.165	0.142	0.277	0.14	yearly	117
Log real GDP per capita	9.441	2.346	0.513	0.235	quarterly	428
Nominal interest rate	13.45	21.96	-20.14	15	quarterly	400
Output growth	2.064	11.185	-0.831	2.751	quarterly	424
Public banks' assets share	25.06	22.72	-41.45	22.91	yearly	117
Foreign banks' assets share	53.52	29.97	56.475	31	yearly	109
Foreign exchange reserves/GDP	1.161	9.178	0.036*	0.085*	quarterly	432
Reserve requirement ratio	8.58	5.45	-3.456	3.702	yearly	432
			Min	**Max**		
Credit transfers per inhabitants††	15.96	13.97	1	67	yearly	48
All non-cash payments per inhabitants††	21.5	17.76	1	90	yearly	52

† excludes Bulgaria

†† data not available for Bulgaria

Correlation matrix

	Inflation	Banking reform index	Public banks' assets share	Foreign banks' assets share	Foreign exchange reserves/GDP
Inflation	1				
Banking reform index	-0.17	1			
Public banks' assets share	0.13	-0.68	1		
Foreign banks' assets share	-0.12	0.57	-0.73	1	
Foreign exchange reserves/GDP	0.03	-0.37	0.21	-0.16	1

Table B: Reduced-form estimates

Panel B1: Trend break on financial intermediation at the reform dates and robustness to alternative sets of control variables
Control variables are lagged by two quarters

	Credit/GDP	Credit/GDP	Credit/GDP
	(1)	(2)	(3)
Post-reform trend break	**0.055****	**0.040****	**0.042****
	(0.019)	**(0.015)**	**(0.016)**
Inflation	0.006*	0.005*	0.005*
	(0.003)	(0.002)	(0.002)
Inflation*(High-inflation dummy)	-0.005**	-0.004*	-0.004*
	(0.002)	(0.002)	(0.002)
High-inflation dummy	0.038**	0.026	0.026
	(0.016)	(0.015)	(0.015)
Expenditure over GDP ratio	-1.137*	-1.294**	-1.294**
	(0.612)	(0.544)	(0.496)
Log real GDP per capita	0.867*	0.768*	0.779*
	(0.409)	(0.379)	(0.359)
Banking reform index	-0.687		-0.712*
	(0.391)		(0.387)
Banking crises	-0.132		0.035
	(0.138)		(0.069)
Public banks' assets share	0.006*	0.006*	0.005*
	(0.003)	(0.003)	(0.003)
Foreign banks' assets share	0.0004	-0.001	-0.001
	(0.003)	(0.002)	(0.002)
Foreign exchange reserves/GDP		0.01***	0.01***
		(0.001)	(0.002)
Country-specific trends	x	x	x
Year-fixed effects	x	x	x
Country-fixed effects	x	x	x
Seasonal dummies	x	x	x
Within R-squared	0.86	0.88	0.89
Number of observations	404	400	400

Note: Robust clustered (at the country level) standard errors in parentheses.

Significant at (*) 10% level; (**) 5% level; (***) 1% level.

Panel B2: Robustness to lag length, subsample variations and control experiment

	Credit/GDP	Credit/GDP	Credit/GDP	Credit/GDP	Credit/GDP	Credit/GDP
	(1)	(2)	(3)	(4)	(5)	(6)
		Two lags excluding non-reform countries	*Four lags on control variables*	*No lag*	*Two lags excluding non-reform countries*	*Control experiment*
Post-reform trend break	**-0.019**	**0.038****	**0.049****	**0.040***	**-0.025**	**-0.009**
	(0.023)	**(0.016)**	**(0.016)**	**(0.019)**	**(0.019)**	**(0.011)**
(Initial currency ratio)*Post-reform trend break) (a)	**0.032****				**0.028***	**-0.001**
	(0.013)				**(0.012)**	**(0.001)**
(Initial total reserves ratio)*Post-reform trend break)	**0.258****				**0.302****	**0.075**
	(0.116)				**(0.099)**	**(0.055)**
Inflation	0.004*	0.006**	0.0002	0.002	0.005**	0.006
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.008)
Inflation*(High-inflation dummy)	-0.003*	-0.005*	-0.0005	-0.00005	-0.003*	0.000
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.094)
High-inflation dummy	0.028**	0.030	-0.002	-0.015	0.033**	-0.094
	(0.012)	(0.019)	(0.02)	(0.032)	(0.013)	(0.048)
Expenditure over GDP ratio	-1.261**	-0.998	0.140	-1.364**	-1.029	-1.724
	(0.459)	(0.740)	(0.520)	(0.578)	(0.735)	(1.087)
Log real GDP per capita	0.769	1.258***	-0.048	0.085	1.202***	0.465
	(0.336)	(0.203)	(0.164)	(0.183)	(0.199)	(0.180)
Banking reform index	-0.856*	-0.791*	-0.566**	-0.821	-0.926**	-0.138
	(0.395)	(0.354)	(0.248)	(0.663)	(0.342)	(0.361)
Banking crises	-0.010	0.087	0.067	0.159	0.032	0.007
	(0.054)	(0.076)	(0.073)	(0.107)	(0.063)	(0.006)
Public banks' assets share	0.005*	0.006	0.003	0.007*	0.006**	-0.001
	(0.003)	(0.004)	(0.003)	(0.003)	(0.002)	(0.004)
Foreign banks' assets share	0.000	-0.0007	-0.002	-0.0001	0.001	-0.107
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.117)
Foreign exchange reserves/GDP	0.009***	0.009***	0.015***	0.011***	0.009***	0.618
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.513)
Country-specific trends	x	x	x	x	x	x
Year-fixed effects	x	x	x	x	x	x
Country-fixed effects	x	x	x	x	x	x
Seasonal dummies	x	x	x	x	x	x
Within R-squared	0.89	0.89	0.88	0.85	0.91	0.92
Number of observations	400	288	380	420	288	112

Note: Robust standard errors in parentheses. Significant at (*) 10% level; (**) 5% level; (***) 1% level.
(a) The currency ratio is the ratio of currency in circulation (oustide the banking system) over demand deposits and the reserves ratio is the ratio
of excess reserves held by private banks over total deposists.

Table C: Transmission channels

	Currency ratio (a)	Excess reserve ratio (a)	Reserve ratio	Currency ratio	Excess reserve ratio
		Fixed Effects		SURE (b)	
	(1)	(2)	(3)	(4)	(5)
Post-reform trend break	-0.015*	0.0003	0.0029*	-0.015***	0.0027**
	(0.007)	(0.0015)	(0.0015)	(0.0026)	(0.0012)
(Trend break)*(Initial level of excess reserves)			-0.049***		-0.045***
			(0.012)		(0.012)
Log real GDP per capita	-0.228*			-0.288***	
	(0.112)			(0.069)	
Government expenditure over GDP ratio	0.923			0.893***	
	(0.587)			(0.319)	
Nominal interest rate	-0.003***	-0.0002	-0.0002	-0.0027***	-0.0002
	(0.0004)	(0.0001)	(0.0001)	(0.0004)	(0.0001)
Output growth		-0.0003*	-0.0003*		-0.0004*
		(0.0001)	(0.0001)		(0.0002)
Reserves requirement ratio		-0.009**	-0.010***		-0.011***
		(0.003)	(0.003)		(0.0012)
Foreign exchange reserves/GDP		0.0001	-0.00005		-0.0002
		(0.0001)	(0.0001)		(0.0002)
Country-specific trends	x	x	x	x	x
Year effects	x	x	x	x	x
Country effects	x	x	x	x	x
Seasonal dummies	x	x	x	x	x
Within R-squared	0.57	0.48	0.50	0.93	0.80
Number of observations	396	392	392	392	392

Note: Robust clustered standard errors in parentheses.
Significant at (*) 10% level; (**) 5% level; (***) 1% level.
(a) The currency ratio is the ratio of currency in circulation (oustide the banking system) over demand deposits and the reserves ratio is the ratio
of excess reserves held by private banks over total deposists.
(b) SURE stands for seemingly unrelated least squares

Table D: Structural model estimates

Dependent variable: shock to credit

	(1)	(2)	(3)	(4)
	Fixed effects		Instrumental variables (b)	
Currency ratio shock (a)	-0.414**		-1.529***	
	0.168)		(0.453)	
Excess reserves ratio shock (a)		0.636		0.439
		(0.469)		(0.300)
Anderson LR statistic weak instrument test			43.37	161.05
Chi-sq(4) p-value			0.00	0.00
Hansen J statistic overidentification test			0.38	1.48
Chi-sq(3) p-value			0.54	0.22
Country-fixed effects	x	x	x	x
Number of observations	374	374	364	360

Note: Robust clustered standard errors in parentheses.

Significant at (*) 10% level; (**) 5% level; (***) 1% level.

Shocks are residuals obtained after estimation of the system of equations **(9)** and **(10)** using seemingly unrelated least squares.

(a) The currency ratio is the ratio of currency in circulation (oustide the banking system) over demand deposits

and the reserves ratio is the ratio of excess reserves held by private banks over total deposists.

(b) We use the second and third lags of the liquidity preference shocks as instruments for contemporaneous shocks

Table E: Relationship between alternative measures of payment systems development and credit

Dependent variable: annual credit over annual GDP ratio

	(1)	(2)
Credit transfers per inhabitant	0.0046***	
	(0.0013)	
All non-cash payments per inhabitant (a)		0.0022*
		(0.0009)
Year-fixed effects	x	x
One-year lagged control variables (b)	x	x
R-squared	0.89	0.79
Number of observations	35	38

Note: Robust clustered standard errors in parentheses.

The sample includes all countries covered previously except Bulgaria.

(a) Including direct debits and cheques.

(**), (***) Stands for significance at 5% and 1% level, respectively.

(b) All control variables as listed in Table B.

Appendix 1: The timing and components of payment systems reforms in the ten sample countries, drawing on publications issued by national central banks

Countries	Date	Brief history
Bulgaria	**2002**	The Bank Integrated System for Electronic tRAnsfers, BISERA (the national settlement system of Bulgaria) was introduced in 1992. Until the introduction of RTGS in 2002, the settlement procedure was built on a queuing facility and an interbank payment transaction was only carried out if the sending bank had sufficient funds on its current account with the Bulgarian National Bank (BNB). If sufficient funds were not available to settle the first payment in the queue, the queued payment remained unprocessed until such funds are received. When a payment, owing to the lack of liquidity of a bank, could not be executed within a period of ten working days after having been entered in the settlement system, the payment was rejected by the settlement system and deleted from the waiting queue. There was an option for some payments to be settled during the same working day directly by the BNB, on the basis of payment orders submitted on paper, or via SWIFT at BNB desks. This express service was organised for all payments addressed to or initiated by the BNB, direct bank-to-bank payments related to interbank money market operations, payments on the primary and secondary government securities market, and some budget payments. The efficient functionality of the new RTGS system, RINGS, helps assure a more efficient liquidity management of commercial banks, improving the efficiency and the security of the payment system, and reducing the systemic and credit risks in the national payment system. The efficiency of the payment system reduced the banks liquidity needs. As under the currency board arrangement the BNB cannot provide funding to commercial banks, a Reserve Guarantee Fund was set up to ensure the settlement of the netting systems with and to mitigate systemic risk.
Czech Republic	**1992**	In 1992 the central bank introduced a new interbank payment system and set up a Clearing and Settlement Centre to handle all domestic currency payments between banks. This made it necessary to introduce a modern, secure, reliable and effective interbank clearing and settlement system. In a very short time (only eleven months after the contract was signed) the necessary technology was installed and the software completed. On 8 March 1992, after fourteen months of development, implementation and testing, the live operation of the Clearing and Settlement System at the central bank's Clearing Centre started. After the division of Czechoslovakia at the beginning of 1993, a new clearing centre was founded in Slovakia, while the former federal Clearing and Settlement Centre remained within the Czech National Bank.
Estonia	**2002**	The first interbank payment system in Estonia, EPNAS, which was owned and managed by Eesti Pank, was operational from 1992 until 2002. At that time EPNAS was the only interbank payment system in Estonia and was used for settlement of both high-value and retail payments. In 2002 Eesti Pank reformed the interbank payment and settlement system and it was split into two systems: RTGS and the Designated Time Net Settlement System (DNS). According to Eesti Pank, the final objectives of the reform were to accelerate settlements, build confidence in the banking sector and reduce the use of cash for high-value transactions. RTGS was needed in order to ensure efficient, fast and secure settlement of payments in Estonian kroons and central bank money, providing a controlled systemic risk environment. In addition, RTGS was needed in order to conform with the payment systems of euro area countries and for the connection with TARGET. The implementation of the new system has allowed commercial banks to widen the choice of services provided to clients and it enables more flexible liquidity management. For bank clients, the new system primarily meant faster movement of payments between banks.
Hungary	**1999**	The launch of the new real-time gross settlement system VIBER in September 1999 is an important milestone in the comprehensive development of the payment systems. Implementation of VIBER is not without antecedents: it carries on paper-based account management services of the National Bank of Hungary. The extended opening hours of the large-value payment system (VIBER) have improved daily liquidity management by the banks. The legal framework has also been strengthened by removing the legal uncertainties that had existed regarding pledges, thereby mitigating the risk involved in repo contracts. This was an important step towards further deepening the domestic money market.
Latvia	**1998**	The new multilateral net settlement system, the EKS, was implemented in November 1998 as a replacement for the paper-based clearing system. The EKS is an automated clearing house system, which handles bulk payments in electronic form. The changeover from paper-based processing of payment orders to electronic exchange was gradual. A transition period of five months was established, during which, in parallel with the EKS, a limited portion of payments were processed in paper form through the manual clearing system. Since the end of this transitional period the Bank of Latvia has accepted only electronic payments in the clearing circuit. The SAMS project was a major undertaking by the Bank of Latvia to modernise the national payment system. The objective of the project was to build an RTGS system that will provide higher operating standards for settlement risk, security, efficiency and capacity in the future. SAMS became fully operational in 2000.
Lithuania	**2004**	The payment system LITAS went live on 19 January 2004 and replaced the paper-based payment system TARPBANK that was operating from 1993. The payment system LITAS is fully automated and was designed to process payment transactions in real time and at a designated time. As from the date of its creation the TARPBANK system has proved to be reliable. However, the requirements for operation, capacity, speed of interbank funds transfer systems and the development of the Lithuanian banking system resulted in the Bank of Lithuania's decision to establish a new system.
Poland	**1994**	During the period in which Poland had a centrally planned economy, the system for interbank settlements was based on the exchange of paper documents. There was no clearing house to intermediate in the exchange of payment orders between banks. Settlement documents were sent between banks by post. Debiting of the current accounts of sending banks and crediting of the current accounts of receiving banks was not performed on the same day. The move towards a market economy triggered a major reform of the payment system. New, uniform principles for interbank settlements in zloty became effective on 5 April 1993. At first these were only binding on shareholders of the National Clearing House (KIR), ie on 17 banks, but, since 1 July 1994, they have applied to all banks operating in Poland. Since then zloty payments in Poland have been processed by two different systems: large-value payments by the RTGS system of Narodowy Bank Polski and retail payments in KIR. The system fulfils the requirements for a modern RTGS system, ie payments are processed electronically in real time on a gross basis and, once settled, are final and
Romania	**2005**	During the second half of 2004 and in 2005 a significant number of goals were achieved in the payment systems field. A large part of the legal framework was harmonised with EU legislation and most of the former infrastructure was gradually replaced by a new fully automated system. Thus, in April 2005, the large-value payment system ReGIS was launched, replacing the previous system in which payment instruments were manually processed and settlement was not final until the end of the operating day. ReGIS is a real-time gross settlement system.
Slovak Republic	**2003**	From January 2003 significant change occurred in the Slovak Interbank Payment System (SIPS) operating since 1993. The National Bank of Slovakia became an operator and at the same time a settlement agent of SIPS, the only interbank payment system in the Slovak Republic. The reason for this change was an effort by the National Bank of Slovakia to boost the effectiveness and safety of the payment system using the state-of-the-art information technology as a base for building up a RTGS system under the conditions of the Slovak Republic.
Slovenia	**1998**	The payment system in former Yugolsavia was prone to systemic risks, and disconnected from the accounts held by the entities at the central bank. Paper-based credit transfers dominated the system and accounted for over 90% of the payments value. In 1998 central bank implemented a new (RTGS) system SIBPS (the Slovenian Interbank Payment System) and a designated time multilateral net settlement system called Giro Clearing.

Appendix 2: Data sources

Variables	Sources
EBRD banking reform index	EBRD website
Credit over GDP ratio	World Bank Fin-structure data set online
	IMF IFS statistics
Gross domestic product	line 99b
GDP deflator	line 99bip
Government spending	line 82
Overnight rate or Treasury bill rate	line 60b
Population	line 99z
Reserve money (currency in circulation)	line 14a
Reserves at central bank	line 20
Demand deposits	line 24
Time, saving and foreign currency deposits	line 25
Public banks' assets share	EBRD database website
Foreign banks' assets share	EBRD database website
Foreign exchange reserves	line 1.d.d
Credit transfers per inhabitants	ECB *Blue Book* 2001
All non-cash payments per inhabitants	ECB *Blue Book* 2001
Reserve requirements ratios	Central banks annual reports and other sources

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