PALMA FILEP-MOSBERGER, LORANT KASZAB, ZHOU REN

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Spillover Effects of Foreign Currency Loans: the Role of the Bank Lending Channel *

(A devizahitelek tovagyűrűző hatásai: a banki hitelezési csatorna szerepe)

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Contents

Abstract

Local currency borrowers are statistically significantly affected by exchange rate fluctuations due to the bank lending channel. Using microdata on borrowers from Hungary, this study examines the spillover effects of foreign currency loans on local currency borrowers following an unexpected appreciation of the Swiss franc (CHF) in January 2015. CHF corporate loans are considered unhedged since the majority of the borrowers did not have income in CHF. Our analysis indicates that banks holding a larger portion of unhedged CHF corporate loans reduced their lending in local currency corporate loans after the shock. This relationship is robust across both extensive (loans terminated by a given bank and no new loans at a bank or banks different from the account holder bank or banks) and intensive (no new loans at its current bank or banks) margins. Further investigation into the mechanisms reveals that banks with more unhedged CHF corporate loans experience an increase in non-performing CHF loans post-shock, reducing their capital adequacy. Furthermore, the evidence in our paper suggests that reductions in banks' local currency lending due to exchange rate shocks adversely affect the investment activity of small firms and increase their likelihood of default.

JEL: G15, G21, G28, G32, G33.

Keywords: bank lending, exchange rate shock, currency mismatch, FX loans, credit.

Összefoglaló

Az árfolyam volatilitása a banki hitelezési csatornán keresztül hatással van a hazai devizában kölcsönt felvevőkre. Hitelszintű magyar mikro-adatokon azt találjuk, hogy a svájci frank 2015 januári nemvárt felértékelődését követően a magyar bankrendszerben levő külföldi devizában denominált adósság negatív átgyűrűző hatással volt a forint-hitelt felvevőkre. A tanulmányunk szerint a nagyobb svájci frank hitelállománnyal rendelkező bankok jobban csökkentették a hazai devizában kínált vállalati hiteleiket a sokkot követően. A svájci frank hitelek fedezetlennek számítottak abban az értelemben, hogy a hitelfelvevők döntő többségének nem volt svájci frankban jövedelme. Az utóbbi összefüggés az extenzív (megszűnt a meglévő összes hitele egy adott banknál vagy nem volt a számlavezető bankján/bankjain kívül új hitele) és intenzív (nem volt a számlavezető bankjánál/bankjainál újabb hitele) határon is robusztus. Továbbá azt is megmutatjuk, hogy a sokkot követően a nagyobb svájci frank kitettséggel rendelkező bankoknál megnőtt a nemteljesítő hitelek aránya, ami negatívan érintette a tőkemegfelelésüket. A hazai devizában való csökkenő hitelkihelyezés a sokkot követően elsősorban a kisebb vállalatok beruházását érintette negatívan, és növelte a csődjelentési valószínűségüket is.

1 Introduction

Borrowing in foreign currencies is common among firms in emerging economies. However, these economies often face exchange rate fluctuations, which can lead to financial distress in firms with foreign currency debt. Open economy macroeconomic models indicate that currency mismatches-where assets denominated in local currency exceed liabilities in foreign currency—are key in transmitting exchange rate risks to firms[1]. When the domestic currency depreciates, the value of foreign liabilities rises in domestic terms, increasing the debt burden. This rise in debt burden is a drag on firm growth and elevates their probability of default, as discussed in seminal works by Krugman (1999) and Céspedes et al. (2004).

Existing empirical studies have focused predominantly on the financial distress experienced by foreign currency borrowers. Nonetheless, it has also often been observed that local currency borrowers, despite not being directly exposed to exchange rate risks, may still be impacted following exchange rate shocks (Verner and Gyöngyösi (2020)). One important reason is that financial intermediaries transmit risks from currency mismatches to local currency borrowers. Following a negative exchange rate shock, loans denominated in foreign currency generate higher losses due to an increased probability of default. This situation can reduce banks' capital and liquidity positions, indirectly impacting other firms through what is commonly referred to in the literature as the "bank lending channel".

This paper explores the spillover effects of exchange rate shocks through the bank lending channel on local currency borrowers, using micro-level data from banks and firms in Hungary. We identify a novel channel whereby, following an exchange rate shock, foreign currency corporate loans become riskier and have a feedback effect on the balance sheets of banks. This, in turn, leads to a contraction in the growth of local currency corporate loans. Previous research on bank lending, such as studies by Bottero et al. (2020) and Jiménez et al. (2020), has demonstrated that the value of bank assets significantly impacts bank lending growth. Based on this, we infer that banks with more foreign currency loans to unhedged borrowers experience a larger decline in loan growth following a depreciation of the local currency. This decline is attributed to the high exposure of these loans to exchange rate risks, which increase the probability of defaults and delays in payment (i.e., credit risk) due to the 'balance sheet effect'. Consequently, these loans generate lower cash flows, impacting the bank's liquidity and capital, and leading to reduced lending to local currency borrowers (Ranciere et al. (2010)).

We study the spillover effects based on the unforeseen appreciation of the Swiss franc (CHF) in January 2015. This event is an ideal setting for two main reasons. First, the CHF appreciation is an unexpected external shock to the Hungarian economy. Second, Hungary, along with other Central and Eastern European (CEE) countries, experienced a notable increase in loans denominated in Swiss francs (CHF) before 2015. As a result, Swiss franc corporate loans became a non-negligible component of bank balance sheets. Therefore, a sizeable appreciation of the Swiss franc is likely to impact the balance sheets of Hungarian banks. In addition, in November 2014, the Hungarian Government implemented a programme converting foreign currency household loans into Hungarian forint (HUF) loans. This intervention is particularly relevant to our study as it effectively shielded households from exchange rate shocks. It helps to refine our identification strategy by eliminating the credit risk associated with household CHF loans. In 2013, the Hungarian Central Bank launched the Funding for Growth Scheme (Növekedési Hitel Program, NHP), with part of the program focused on converting small and medium-sized enterprises' foreign currency loans into local currency. Although the program successfully reduced the volume of corporate loans denominated in Swiss francs (CHF), 3.7% of these loans remained CHF-denominated.

To investigate the bank lending channel of exchange rate shocks, we use loan-level data from the Hungarian credit registry. Our identification strategy employs difference-in-difference regressions with firm fixed effects, focusing on firms that borrow from multiple banks. This approach allows us to distinguish the effects of changes in credit supply from concurrent shifts in firms' credit demand and creditworthiness Khwaja and Mian (2008). Our main independent variable is the banks' relative size of CHF

[1] In emerging economies, many firms borrow in foreign currency without a natural hedge because local currency interest rates are usually higher than foreign currency interest rates. This strategy resembles a "carry trade", where firms borrow in foreign currency, anticipating stable exchange rates. Additionally, access to financial hedging tools is generally limited to non-financial firms, with only the largest firms typically having access to such tools.

corporate loans to unhedged borrowers, measured by the loan volume-to-total assets ratio. This ratio serves as a proxy which measures the exposure to increased credit risk associated with CHF corporate loans. Our loan-level analysis yields several key findings. When comparing loans to the same firm borrowing in local currency from two banks with a one standard deviation difference in their CHF corporate loan ratio, we observe that the bank with more CHF corporate loans shows local currency lending growth that is on average 10.23 percentage point lower than its counterpart after controlling for firm demand[2]. This result suggests that banks with more CHF corporate loans exhibit poorer performance in extending credit in local currency. This confirms that the risks from foreign currency loans transmit to local currency borrowers through the bank lending channel.

To control for concurrent policy effects and variations in the structure of the bank balance sheet, we incorporate in the baseline loan-level regressions other control variables such as the pre-shock CHF household loans relative to total assets, net CHF positions both on- and off-the balance sheet, and other bank characteristics. Despite these measures, concerns remain that our results could be influenced by other factors, such as additional simultaneous policy effects and changes in external market funding conditions. We address these concerns in our robustness tests. First, one of the contemporaneous policy events involves a compensation requirement imposed on banks to reimburse household borrowers for past excess interest rate charges and excess exchange rate margins. We calculate and include the volume of this compensation for each bank as a control variable and find that it does not impact our main results[3]. Second, we exclude large firms, which are more likely to access market funding compared to the smaller firms that comprise most of our sample, to assess the influence of changes in market funding; our findings remain unchanged. Third, we employ a placebo regression estimated two years before the exchange rate shock to test the parallel trend assumption. This regression reveals no statistically significant effects of CHF corporate loans on bank lending. Fourth, we use alternative dependent variables to examine how the CHF corporate loan to total asset ratio affects both the extensive and intensive margins of credit supply, further confirming the robustness of our findings.

We further investigate the transmission mechanism through which exposure to risks from CHF loans influences bank lending activities after an exchange rate shock. Our findings reveal that banks with greater exposure witness an increase in the ratio of non-performing CHF loans to total loan assets. This correlation is apparent not only in loans overdue by more than 90 days but also in those with payment delay between 30 and 90 days, indicating additional new payment delays. Such evidence strongly supports the assertion that exchange rate shocks intensify banks' credit losses from CHF denominated loans. We also demonstrate that increased exposure to risks from CHF loans is associated with a decline in banks' capital adequacy ratios. Furthermore, we conduct regressions that consider the interaction between exposure and banks' capital and liquidity positions, based on the observation that banks with higher capital and liquidity ratios are better equipped to mitigate reductions in credit supply. Taken together, our results suggest that unexpected exchange rate shocks impact the default rates and cash flows of CHF corporate loans. Consequently, banks with a higher volume of CHF corporate loans experience greater reductions in liquidity and statistically significant capital losses, which in turn compel these banks to tighten credit supply in local currency.

Building on our loan-level analysis, we explore the real effects of the bank lending channel using firm-level regressions. The primary independent variable is firms' indirect exposure to the exchange rate risk when possessing CHF loans which are calculated as a loan volume-weighted average of bank-level exposure[4]. At the firm level, we employ OLS regression, as within-firm fixed effect regression is not feasible. In line with the findings of Khwaja and Mian (2008), we show that our loan- and firm-level OLS regressions tend to underestimate the effects compared to fixed effect regression, allowing us to conservatively estimate the firm level bank lending channel[5]. We conduct firm-level analyses in both the main sample comprising only firms borrowing from multiple banks and a broader sample that also includes firms borrowing from only one bank. We start from examining whether firms can offset reduced bank lending by securing loans from other banks within the sample. Our findings indicate that this typically does not occur, as total firm-level credit statistically significant decreases with their indirect exposure to CHF corporate loans.

[2] A back-of-the-envelope calculation suggests that the aggregate impact of the CHF shock resulted in a 0.85 percentage points decline in local currency corporate lending growth in Hungary between Q4 2014 and Q4 2015. In particular, the aggregate effect is calculated, for our sample of 44 banks, as $\sum_{i=1}^{44} * sd_i * \hat{\beta}_1 * \omega_i$, where sd_i is bank i's standardized distance of CHF loans-to-total assets from 0, $\hat{\beta}_1$ is the estimated 10.23 percentage points change in lending between high and low mismatch banks with a distance of one standard deviation (see footnote 21 for more details on the calculation), and ω_i is bank i's share of HUF corporate loans in all banks in 2014:Q4.

[3] Hereinafter, this policy event is referred to as 'interest rate compensation.'

[4] All firms in the analysis are local currency borrowers.

[5] To mitigate potential bias, we incorporate firm fixed effects derived from loan-level regressions as a control, following Cingano et al. (2016).

Subsequently, we analyse how changes in bank lending impact real measures of firm activity such as capital formation at the firm level. We also explore how the availability of credit affects the probability of firm default. For firms with loans from multiple banks, a contraction in bank lending does not significantly affect firm investment, despite influencing overall credit availability of firms. This may be due to these firms generally being larger and more profitable, which enables them to sustain operations through internal funding. However, in the broader sample that includes all firms, where most have borrowing relationships with only one bank, smaller firms demonstrate a significantly reduced capacity to remain solvent and invest capital.

Related literature Our research draws from several strands of literature. First, a substantial body of work within international finance literature focuses on the implications of private sector foreign currency debt. Studies in this domain typically examine the broader economic impacts of foreign currency indebtedness[6]. More recently, several micro-level empirical studies have shown that, in currency crises, borrowers with foreign currency debt significantly exhibit higher default rates, negatively impacting their performance and the growth rates of the regions in which they operate. For instance, Kim et al. (2015) demonstrates that small firms with foreign-currency denominated debt faced adverse economic outcomes during the 1997–1998 crisis in Korea. Similarly, Verner and Gyöngyösi (2020) shows that households' exposure to foreign currency debt risks during Hungary's late-2008 currency crisis led to significant negative local and regional effects.

The second strand of literature investigates the transmission mechanisms of exchange rate shocks through the bank lending channel. For example, Agarwal (2018) and Abbassi and Bräuning (2021) explore how fluctuations in exchange rates affect bank lending behaviours, with a particular focus on banks' currency mismatches both on- and off-the-balance sheet in advanced economies[7].

Our study offers a distinctive perspective by bridging two streams of literature. It investigates the relationship between foreign currency loans and bank lending behaviours, demonstrating how risks associated with foreign currency mismatches can adversely affect the credit supply to local currency borrowers which share the same lending institutions. This analysis underscores that local currency borrowers can also experience statistically significant adverse effects following an exchange rate shock. Distinct from previous research which predominantly focuses on advanced economies, our study places special emphasis on emerging markets[8].

Furthermore, our study deepens the understanding of how economic shocks can spill over to borrowers and lenders not directly exposed to such shocks. A recent paper by Galaasen et al. (2020) demonstrates a similar mechanism to us: the authors employ a Granular Instrumental Variable method to show that the aggregation of idiosyncratic borrower risk significantly reduces banks' portfolio returns. This, in turn, spills over through lending to other firm borrowers, reducing their investment.[9] While our study shares a similar mechanism with Galaasen et al. (2020), our identification strategy relies on a well-defined aggregate shock rather than the aggregation of idiosyncratic shocks. Specifically, we observe that lending to unhedged foreign currency borrowers leads to a reduction in domestic currency-denominated credit to firms following an exchange rate shock. This suggests that the credit risks associated with foreign currency lending affect banks' balance sheets and create spillover effects on other local currency borrowers through the bank lending channel.

Lastly, our analysis contributes to another strand of literature that examines the transmission of banking activities to the real economy. Numerous empirical studies have shown how shocks to banks can lead to lending contractions that subsequently impact the real economy. For instance, works by Khwaja and Mian (2008), Schnabl (2012), and Cingano et al. (2016) demonstrate that firms borrowing from banks experiencing liquidity shortages face reduced credit availability and lower investment growth. Research focusing on the European sovereign debt crisis, such as studies by Popov and Van Horen (2015), De Marco (2019), and Bottero et al. (2020), has highlighted how negative asset quality shocks can lead to contractions in credit supply. Conversely, Jiménez et al. (2020) investigate the effects of positive asset quality shocks on banks. Our study augments this body of literature by illustrating the critical role of the bank lending channel in the transmission of exchange rate shocks.

[6] Key works include Krugman (1999), Chang and Velasco (2001), Schneider and Tornell (2004), and De Ferra et al. (2020).

[7] Agarwal (2018) examines the impact of net foreign currency asset positions on bank balance sheets, representing direct exposure to currency mismatches. Abbassi and Bräuning (2021) considers mismatches across both on- and off-balance sheet foreign currency positions.

[8] To the best of our knowledge, this is the first study to explore how the bank lending channel transmits exchange rate shocks to corporate borrowers of domestic currency in emerging markets.

[9] Other studies, such as Huber (2018), suggest that contractions in bank lending can adversely affect other local firms through demand spillovers. Our research identifies a reverse spillover channel, where bank lending itself acts as the conduit.

The paper is organised as follows: Section 2 provides institutional background and details the measurement of exposure to CHF corporate debt risk. Section 3 discusses the empirical framework and presents summary statistics of the data. Section 4 and Section 5 report the results of the bank lending channel analysis at the loan and firm levels, respectively. Finally, Section 6 offers the conclusions.

2 Institutional background and Hypotheses Development

2.1 INSTITUTIONAL BACKGROUND

Prior to 2015, private borrowers in Central and Eastern European (CEE) countries, including Hungary, were significantly exposed to CHF currency risk due to a widespread trend known as 'Swiss francisation'. Many borrowers opted for loans denominated in CHF, which constituted an important portion of total bank assets. In Hungary, for instance, Swiss franc assets accounted for approximately 13% of total bank assets by the end of 2014, with Swiss franc loans comprising 10.7% of the total assets [10]. Figure 1 shows the evolution of private loan currency denomination in Hungary from 2012:Q1 to 2018:Q1, highlighting that a significant portion of both corporate and household loans were denominated in Swiss francs before 2015:Q1.

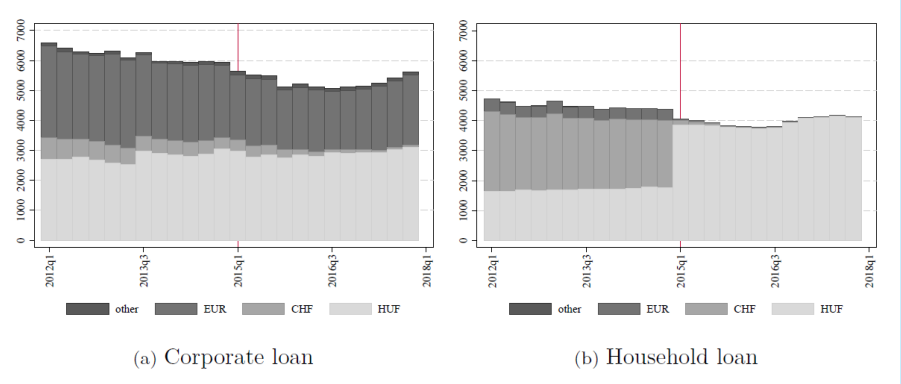
The stability of the CHF exchange rate and comparatively lower interest rates made loans denominated in Swiss francs an attractive option for borrowers in the Central and Eastern European (CEE) region. However, this choice led to significant currency mismatch risks for borrowers, which were exacerbated when the Swiss National Bank (SNB) ended its policy of maintaining a minimum exchange rate of 1.2 Swiss francs per euro on 15 January, 2015. This sudden policy shift resulted in the Swiss franc appreciating by nearly 20% (as shown in Figure 2), causing substantial financial distress for many unhedged CHF borrowers across various CEE countries. The unexpected exchange rate shock increased outstanding household and firm debt in local currency terms and raised the ratio of non-performing loans on bank balance sheets (see Fischer and Yeşin (2022)). Although bank regulations generally prohibit banks from holding large net foreign currency positions, often referred to as total direct mismatch (including both on- and off-balance sheet items), the main factor behind the impaired bank balance sheets after the shock was the indirect mismatch caused by the rise in non-performing loans.

Unlike other Central and Eastern European (CEE) countries, Hungary implemented a timely and effective policy in the household sector that mitigated the adverse effects of the CHF shock. On 7 November, 2014, the Hungarian Parliament passed legislation enabling the Central Bank of Hungary (Magyar Nemzeti Bank, MNB) to convert all foreign currency-denominated household mortgage loans into HUF-denominated loans[11]. Additionally, the Central Bank provided foreign reserves to banks to close their foreign currency short positions. Although actual implementation began in February 2015, the conversion rate was fixed at the market rate of the announcement day. Consequently, between the dates of the conversion legislation and the shock, household loans denominated in CHF were still recorded as foreign currency assets for accounting purposes, but economically, they were already considered as local currency assets and were not sensitive to the exchange rate shock. This preventive policy, enacted shortly before the CHF exchange rate shock, effectively shielded the household sector from subsequent currency fluctuations. As a result, unlike other CEE countries, there were no household defaults on CHF loans due to the exchange rate shock in Hungary. Overall, this policy prevented insolvency of households. Still unhedged firms with CHF loans remained vulnerable to unexpected movements in the CHF/HUF exchange rate. The conversion policy provides an ideal setup for isolating the simultaneous effects from CHF household borrowers when studying spillover effects from risky CHF corporate loans to local currency borrower firms.

[10] Notably, in Hungary, CHF debt held by households and non-financial corporations represented about 21.7% and 3.7% respectively, of total outstanding debt in 2014.

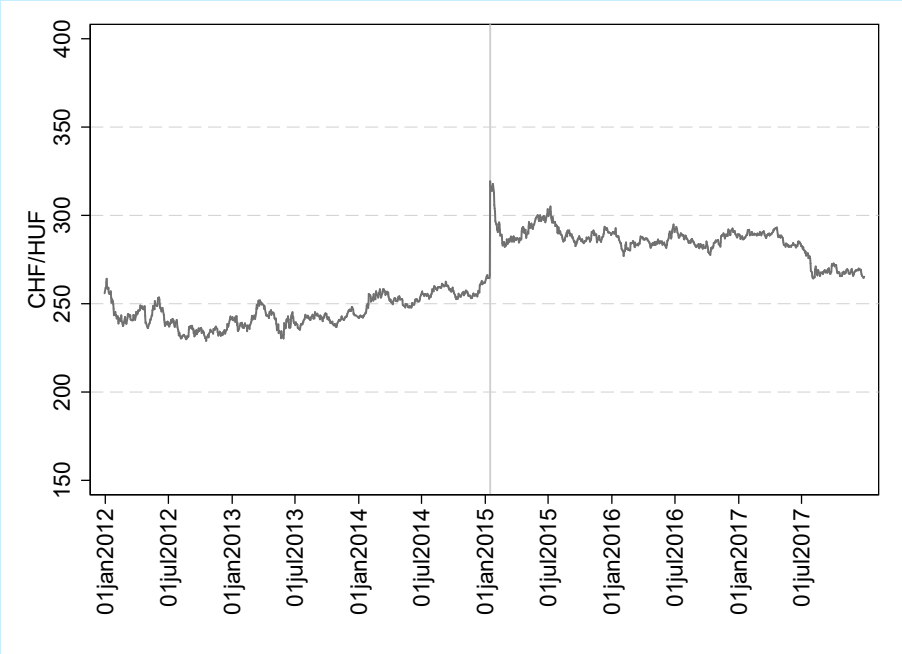
[11] The initial motivation of this policy was not specifically aimed at the shock analyzed in our study, as this shock was unexpected. Instead, it primarily targeted the longstanding issue of CHF mismatch risk for households, which had previously demonstrated detrimental consequences in 2008, as analyzed in Verner and Gyöngyösi (2020). However, the timing of this policy, enacted just before the 2015 shock, proved fortuitous, effectively protecting CHF household borrowers immediately after its enactment.

Figure 1
Dynamics of corporate and household loans in Hungary



Notes: The figure depict the evolution of corporate a) and household b) loans in Hungary from 2012:Q1 to 2018:Q1, incorporating data from 44 Hungarian banks included in our sample. The numbers represent the actual outstanding capital values of loans, calculated using end-of-quarter exchange rates. The values on the X-axis are expressed in billions of forints. Data source: MNB.

Figure 2
Exchange rate around the shock



Notes: This figure shows the daily nominal CHF/HUF exchange rates from 2012 to 2017. Data source: MNB.

2.2 HYPOTHESES DEVELOPMENT

In this section, we describe the mechanism through which the bank lending channel transmits the risk associated with CHF-denominated corporate loans to local currency borrower firms during the CHF shock. CHF-denominated corporate loans involve currency mismatches and remained on bank balance sheets even after the phase-out of households' foreign currency debt[12]. Switzerland is not among the top 20 export partners of Hungary, with an export share of less than 1% according to the World Integrated Trade Solution (WITS). Consequently, it is unlikely that non-financial firms with CHF liabilities generate revenues in Swiss francs. This leads to currency mismatches between income and liabilities on their balance sheets. When the domestic

[12] Sample data reveals that 95% of CHF corporate loans on bank balance sheets in 2014 originated before 2009. A.1 provides a breakdown by issuing year for CHF corporate loans in 2014 from our 44 sample banks.

currency depreciates relative to the Swiss franc, these mismatches increase the debt burden, exposing CHF borrowers to elevated credit risk. This, in turn, can impact banks adversely, as borrowers with CHF-denominated loans tend to exhibit higher default rates or experience prolonged periods of late payments. In both cases, banks need to increase loan loss provisions, which decreases their profitability and capital (Bruno and Shin (2019); Niepmann and Schmidt-Eisenlohr (2022)).

Banks with a higher proportion of CHF corporate loans on their balance sheets are more exposed to increased credit risk and are more likely to reduce lending following the CHF shock[13]. Previous literature, such as Van den Heuvel et al. (2002), Galaasen et al. (2020), and Accornero et al. (2017), has both theoretically and empirically documented that a sudden increase in credit risk or non-performing loans is linked to contractions in bank lending. This reduction in lending can be attributed to both capital constraints and liquidity shortages. Bank capital functions as a buffer, enabling banks to absorb potential losses. Regulatory or internal risk management policies typically require that this capital buffer meets a specific threshold relative to the proportion of risky assets, a requirement known as the capital constraint. When a bank approaches this limit, an increase in credit risk forces banks to raise their loan loss provisions, which in turn necessitates a reduction in lending to shrink the balance sheet, thereby enhancing the capital buffer to meet capital requirements (Accornero et al. (2017)).

Furthermore, a decline in profitability can reduce available capital, as banks often allocate profits to build 'free bank capital' (Gambacorta and Shin (2018)). A decrease in profitability can lead to a reduction in this free capital, which banks typically use as additional liquidity to finance new loans. More importantly, as shown in studies by Bernanke and Gertler (1995) and Gertler and Kiyotaki (2010), the size of the external finance premium — the cost banks face in obtaining funds — is inversely related to the capital held by banks. Consequently, a drop in profits exacerbates agency problems between banks and funding providers, making it more challenging for banks to secure funding (Bolton and Freixas (2006); Van den Heuvel et al. (2002)). This situation leads to liquidity shortages and further reduces the credit supply.

Building on the previous discussion, we formulate the following hypotheses:

- Hypothesis 1: Banks with greater exposure to risky CHF lending to unhedged firms prior to the appreciation shock significantly reduce their credit supply in local currency following the shock.

This hypothesis concentrates on the credit supply in local currency because local currency borrowers are not directly exposed to the exchange rate shock. Consequently, their reactions primarily reflect the effects of bank lending rather than the direct consequences of currency mismatches or other exchange-related factors. Additionally, previous research has documented significant impact of changes in credit supply on firm performance. Based on Hypothesis 1, we propose another hypothesis concerning the real effects at the firm level:

- Hypothesis 2: Local currency borrowers, who borrow from banks with high exposure to risky CHF corporate loans, experience a greater decline in firm performance, measured as investment in physical (tangible) capital, in the period following the shock.

To validate our hypothesis, we need a measure that captures the extent of a bank's exposure to unhedged CHF loans. This measure should reflect the sensitivity of bank balance sheets and income flows to increased credit losses from CHF corporate loans in the event of exchange rate shocks. We quantify this exposure by calculating the proportion of CHF lending to non-financial and non-exporting firms relative to the total assets of bank b:

$$\text{CHFLoan}_b = \frac{\text{CHF lending to unhedged firms}_b}{\text{Total bank assets}_b}$$

Banks with a higher proportion of CHF lending to unhedged firms, standardized by bank assets, are expected to experience a greater share of credit losses following a CHF appreciation. It is important to note that this measure should be considered an upper limit, as it assumes that all non-financial and non-exporting firms are unable to hedge their CHF liabilities against exchange rate risks[14]. We exclude CHF loans to households from our analysis due to the timely and effective conversion programme that

[13] The underlying rationale is that banks with a larger share of a specific asset type are more significantly impacted when the quality of that asset deteriorates. Previous empirical literature supports this notion. For instance, Bottero et al. (2020) found that during the European sovereign debt crisis, Italian banks with higher levels of sovereign debt reduced their lending. Similarly, Jiménez et al. (2020) showed that Spanish banks with greater exposure to housing assets increased their lending more in response to rising house prices.

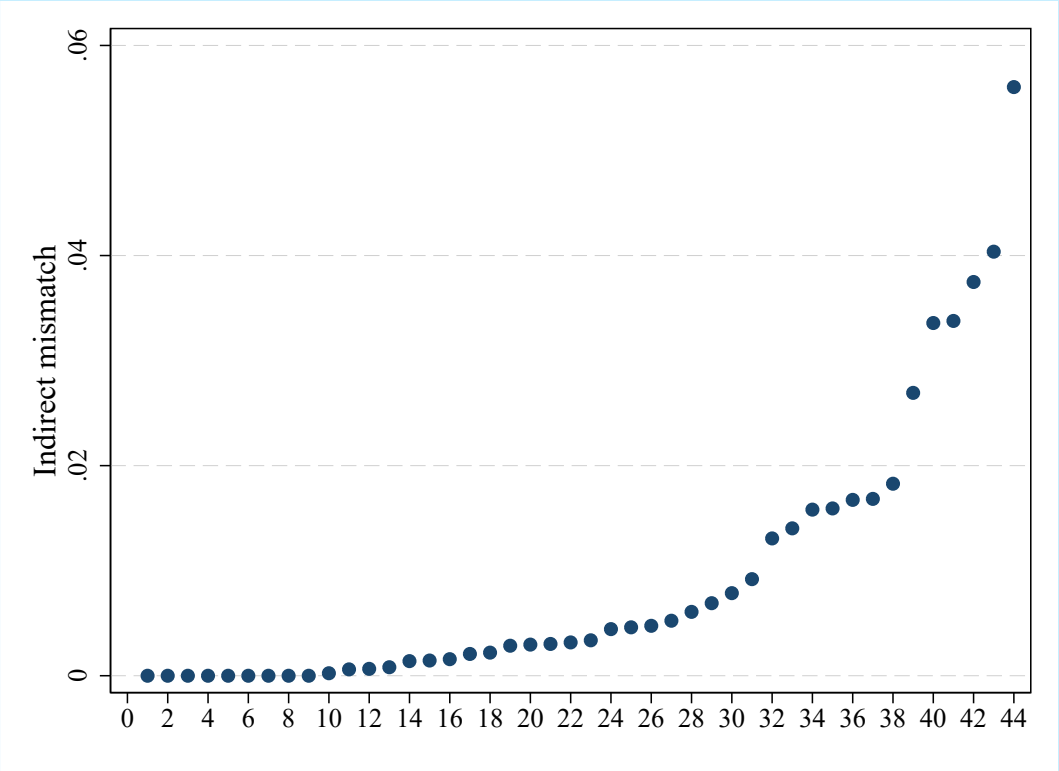
protected households from exchange rate shocks, thereby preventing increased credit losses on household loans. Table 1 and Figure 3 present summary statistics and distribution plots for the CHF corporate loan-to-total assets ratio across our sample of 44 banks. The data shows considerable variation in this ratio among the banks.

Table 1
Summary Statistic: CHF Corporate Loan Ratio

	Obs	Mean	Sd	Pc10	Pc90
CHF lending ratio	44	0.0094	0.0131	0.0000	0.0336

Notes: This table provides summary statistics for the ratio of unhedged CHF corporate loans to total assets among the 44 sample banks.

Figure 3
Distribution: CHF Corporate Loan Ratio



Notes: This plot provides distribution for the ratio of unhedged CHF corporate loans to total assets among the 44 sample banks.

[14] At the end of 2014, there were a total of 4,462 firm loans denominated in CHF on the balance sheets in the sample of our 44 banks. Among these, only 250 loans were extended to exporters, accounting for just 5.6% of the total CHF corporate loans. Additionally, not all of these 250 loans necessarily have a natural hedge, as we cannot observe the specific export destinations; we only know that the firms are exporters. These exports are not necessarily directed to Switzerland, which, as previously mentioned, was not even among the top 20 export destinations back then.

3 Empirical framework and data description

3.1 EMPIRICAL FRAMEWORK

3.1.1 LOAN-LEVEL BANK LENDING CHANNEL

We adopt the firm fixed effect framework from Khwaja and Mian (2008) (hereafter referred to as the KM framework) to analyse the post-shock bank lending channel at the loan level. Consistent with the KM framework, our analysis focuses on firms with HUF-denominated loans from multiple banks. We incorporate firm fixed effects to control for firm-specific variations in credit demand. The first-difference estimation is formulated as follows:

$$\Delta \text{loans}_{b,j} = \beta_0 + \beta_1 \textit{CHFLoan}_b + \Gamma X_b + \rho_j + \epsilon_{b,j} \quad (1)$$

Where $\Delta \text{loans}_{b,j}$ represents the normalised change in the size of a lending relationship between bank b and firm j before and after the CHF exchange rate shock. $\textit{CHFLoan}_b$ measures the bank's CHF corporate loan holding ratio, using the latest quarterly data prior to the CHF appreciation (2014:Q4). X_b includes a set of bank controls, such as the banks' net CHF asset positions, both on and off the balance sheet, to capture direct currency mismatch exposure[15]. We also use the CHF household loan-to-assets ratio as a proxy to control for possible impacts from the simultaneous conversion programme[16]. ρ_j represents the firm fixed effects, which controls for unobserved, firm-specific changes in credit demand. This approach is akin to a within-firm difference-in-difference analysis, where banks with lower CHF corporate loan holdings before the CHF appreciation serve as controls for those with higher holdings.

In our empirical analysis, we focus on a sample of firms that maintain borrowing relationships with multiple banks in 2014, and have loans exclusively denominated in HUF both in 2014 and 2015. We select these firms because they do not have liabilities in Swiss francs and are, therefore, not directly impacted by fluctuations in the CHF exchange rate. This selection criterion allows us to investigate the spillover effects of the exchange rate shock on borrowers who lack direct exposure.

Our analysis incorporates firm fixed effects. Without these fixed effects, using a standard ordinary least squares (OLS) estimator might lead to biased estimates of the bank lending channel coefficient β_1. This potential bias is especially concerning when the CHF corporate loan ratio correlates with unobserved, firm-specific changes in credit demand Bottero et al. (2020). For instance, a firm in a region heavily indebted in Swiss francs may experience an economic downturn following an appreciation of the Swiss franc, consequently reducing the firm's credit demand[17]. This scenario could result in a negative correlation between the firm-specific credit demand and the CHF corporate loan ratio of the bank(s) it borrows from. Conversely, if a firm is located in a region with a high concentration of exporters to Switzerland, an appreciation of the Swiss franc could increase these exporters' cash flows and stimulate the local economy, potentially creating a positive correlation between firm-specific demand and the CHF corporate loan ratio. Using an OLS estimator to determine the coefficient, represented by $\hat{\beta}_1^{OLS} = \beta_1 + \frac{Cov(\textit{CHFLoan}_b, \rho_j)}{Var(\textit{CHFLoan}_b)}$, might lead to overestimation or underestimation of the actual β_1. The KM framework addresses this issue by comparing loan growth for the same firm across different banks. By including firm fixed effects, we can account for variations in firm-specific credit demand, thus enabling us to estimate the unbiased bank lending effect, $\hat{\beta}_1^{FE}$.

[15] Generally, regulations require banks to maintain very low total foreign asset open positions, on and off the balance sheet, to manage their exposure to exchange rate risk. This is also supported by our data.

[16] Additional control variables include: (1) the loan-to-deposit ratio, (2) a dummy for low tier one capital, (3) the capital adequacy ratio, (4) the loan loss provision-to-risk-weighted assets ratio, (5) the total deposits-to-liability ratio, (6) the return on assets, (7) the liquidity to risk-weighted assets ratio, (8) the interbank deposits in liabilities-to-risk-weighted assets ratio, all measured as 2014 yearly averages.

[17] The successful conversion program insulated households from these effects. Consequently, in our analysis, we can control for the confounding influences of bank lending adjustments due to distressed demand of households, thereby refining our identification strategy.

However, even when controlling for firm-specific fixed effects, biases may still arise if the shock is anticipated (Khwaja and Mian (2008); Bottero et al. (2020)). In such cases, banks and firms might adjust their lending relationships in advance, resulting in our estimates reflecting expectation effects rather than true bank lending effects. To address this issue, our study focuses on a specific, unexpected event: on 15 January, 2015, the SNB abruptly abandoned its currency peg of 1.20 to the euro. This decision led to an immediate 20% appreciation of the Swiss franc and was widely regarded as unexpected[18]. Market forward rates from 14 January support this assertion[19], indicating no market anticipation of the event and an expectation that Switzerland would maintain its euro peg. Therefore, we consider this event as exogenous and unexpected for the Hungarian economy. This assumption allows us to exclude strategic or precautionary adjustments by banks and firms from our analysis.

3.1.2 FIRM-LEVEL CORPORATE BEHAVIOR

After examining the bank lending channel at the loan level, we expand our analysis to the firm level. We explore whether firms can counteract credit contraction by securing credit from alternative lenders, thereby maintaining operational stability. To investigate the firm-level effect, we first quantify the extent of local currency borrowers' indirect exposure to the risk associated with unhedged CHF corporate loans, hereafter referred to as 'indirect exposure'. We calculate this indirect exposure using a loan size-weighted average of the bank CHF corporate loan ratio for each local currency borrowing firm. Let B_j represent the set of all banks lending to firm j in Hungarian forint in 2014. The weighted average indirect exposure for firm j is calculated as follows:

$$\textit{CHFLoan}_j^{AVE} = \sum_{b \in \mathrm{B}_j} w_{bj} \times \textit{CHFLoan}_b \tag{2}$$

Here, w_{bj} denotes the percentage of loans firm j has borrowed from bank b relative to the total HUF-denominated credit extended to firm j by all banks in 2014, before the currency shock.

In the firm-level analysis, we encounter similar identification challenges as those in the loan-level regression. However, we cannot include firm fixed effects as before because the unit of observation shifts from a loan relationship to a firm (Schnabl (2012)). To address these challenges in estimating firm-level effects, we incorporate several sets of control variables. First, we include industry and region fixed effects to account for spatial clustering and industry specialisation, which can significantly influence firm demand (Bottero et al. (2020)). Second, we add a set of firm-specific controls measured in 2014, which are crucial determinants of the variations in firm-specific demand. Third, we use the fitted firm fixed effects, $\hat{\rho}_j$, from the loan-level analysis as a control in the firm-level regressions. In particular, $\hat{\rho}_j$ is a vector of parameters characterizing firm-specific credit demand, providing valuable insights into the characteristics of firm-specific demand (Cingano et al. (2016)). Previous research shows that these estimated fixed effects correlate with variables related to credit demand, such as the expected investment rate (Cingano et al. (2016); Bottero et al. (2020)).

We examine the impact of indirect exposure to exchange rate risk on various firm-level outcomes (y_j) using the following regression model:

$$y_j = \alpha_0 + \alpha_1 \textit{CHFLoan}_j^{AVE} + \Gamma X_j^{AVE} + \Pi V_j + \rho^{industry} \times \rho^{region} + \hat{\rho}_j + \mu_j \tag{3}$$

where $\textit{CHFLoan}_j^{AVE}$ represents the loan-size weighted average of a firm's indirect exposure to CHF corporate loans, and X_j^{AVE} denotes the weighted average of bank-specific variables. The vector V_j includes firm-level controls, capturing key firm characteristics[20]. $\rho^{industry}$ and ρ^{region} are fixed effects for industry and county, respectively, allowing for control over sectoral and geographical influences. $\hat{\rho}_j$ represents the estimated firm fixed effect from loan-level regression, accounting for unobserved, firm-specific factors influencing outcomes.

[18] A Bloomberg survey of 22 economists, conducted between 9 and 14 January , 2015, revealed no anticipation of the SNB abandoning its peg within a year. Source: Bloomberg News "SNB Unexpectedly Gives Up Cap on Franc, Lowers Deposit Rate" on 15 Jan, 2015.

[19] Forward exchange rates (overnight, 1 week, 1, 2, and 3 months) all registered at 1.2 on the day before the event, signalling stable investor expectations regarding the exchange rate—see: Auer et al. (2021). Additionally, Jermann (2017) argue that options pricing before 15 January indicated a low probability of the rate floor being scrapped.

[20] Firm-level controls include log revenue, log size, employment, profit ratio, leverage, a dummy variable for foreign ownership, and firm age, all measured at the end of 2014.

Table 2
Summary statistics of loan-level indicators

	Obs	Mean	Sd	Pc10	Pc90
Panel A : multi-borrowing firm					
log HUF amount (2014)	9714	16.71	1.90	14.85	19.03
g(loan)	7984	0.01	0.84	-0.36	0.42
gm(loan)	10052	-0.27	0.93	-2.00	0.48
Panel B : multi and single borrowing firm					
log HUF amount (2014)	44905	16.27	1.81	14.26	18.45
g(loan)	39328	0.02	0.60	-0.32	0.41
gm(loan)	52790	0.10	1.05	-2.00	2.00

Notes: This table presents summary statistics for the loan-level variables used in our empirical analysis, specifically focusing on loans issued in Hungarian forint to firms that do not borrow in other currencies. Panel A contains data from firms that have loans from at least two different banks as of 2014. Panel B includes all firms that received loans denominated in Hungarian forint during the same period. The variable $g(loan)$ calculates the logarithmic growth rate of loans but excludes data from firm-bank pairs that had zero loan balances in either 2014 or 2015, thus capturing changes along the intensive margin only. The variable $gm(loan)$ represents the standardised growth rate, encompassing a broader dataset that includes credit changes along both the intensive and extensive margins, including those firm-bank pairs that had zero loan balances in either 2014 or 2015.

3.2 DATA AND SUMMARY STATISTICS

Our analysis utilises several high-quality, detailed micro-datasets. Our primary data source is the Hungarian Central Credit Information System (Központi Hitelinformációs Rendszer), which provides detailed quarterly credit information for each contract, including the original loan amount, outstanding amount, maturity and currency denomination. For each quarter, we aggregate the amounts of all contracts between the same bank and firm into a "loan". The term "loan amount" refers to the amount specified in the signed contract, not the actual outstanding capital debt. We focus our analysis primarily on a two-year period surrounding the CHF shock. Specifically, we define a pre-crisis period (from 2014:Q1 to 2014:Q4) and a post-crisis period (from 2015:Q1 to 2015:Q4). The primary dependent variable in the estimation of our bank lending channel is the standardised loan growth rate, which measures the change in the size of a lending relationship from bank b to firm j before and after the CHF exchange rate shock. We calculate the standardised loan growth rate using the following two steps. First, we collapse the quarterly loan amounts between bank b and firm j into pre-shock and post-shock averages. Then we calculate the standardised growth rate between these averages following Chodorow-Reich (2014):

$$gm(loan_{b,j}) = 2 \times \frac{loan_{b,j,post}^{average} - loan_{b,j,pre}^{average}}{loan_{b,j,post}^{average} + loan_{b,j,pre}^{average}}$$

where the standardized growth rate $gm(loan_{b,j})$ represents a second-order approximation of the log difference growth rate around zero and is bounded in the range of $[-2, 2]$. These bounds limit the influence of outliers and accounts for changes in credit along both the intensive and extensive margins. Additionally, we also calculate a simple log growth rate ($g(loan_{b,j})$) between the pre-shock and post-shock averages, which captures only the change along the intensive margin.

Table 2 presents summary statistics for loan-level variables. Our analysis focuses exclusively on firms with loans denominated in Hungarian forints, excluding loans in other currencies. As illustrated in Equation 1, the baseline regression estimates the bank lending channel at the loan level using firm fixed effects. For this baseline regression, we limit our primary sample to firms that had only HUF-denominated loans in 2014 and 2015 and maintained borrowing relationships with multiple banks in 2014. These firms are identified as multi-borrowing firms. Table 2 indicates that loans to multi-borrowing firms are, on average, larger in amount compared to the full sample, which includes both multi-borrowing firms and those with only one borrowing relationship, referred to as single-borrowing firms. Additionally, loans to multi-borrowing firms exhibit a lower standardized growth rate from 2014 to 2015.

To examine the effects of the bank-lending channel on firms, we combine data from the Corporate Credit Registry with corporate tax filings from the National Tax and Customs Authority. This integration provides comprehensive information on financial

Table 3
Summary Statistic: Firm-level Indicators

	Obs	Mean	Sd	Pc10	Pc90
Panel A : multi-firm					
Log revenue	4520	12.17	1.74	10.14	14.29
Log balance sheet size	4571	11.91	1.75	9.95	14.16
Employment	4494	39.74	360.71	2	51
Profit to balance sheet ratio	4571	-0.08	7.53	-0.001	0.19
Leverage	4571	3.71	187.17	0.26	0.88
Foreign ownership	4602	0.02	0.15	0.00	0.00
Age	4602	15.82	6.94	7.00	25.00
Annual real total capital growth	4360	0.03	0.65	-0.29	0.47
Panel B : multi and single firm					
Log revenue	43921	11.27	1.77	9.16	13.44
Log balance sheet size	45175	10.91	1.80	8.85	13.19
Employment	42698	16.86	141.49	1.00	25.00
Profit to balance sheet ratio	45175	-0.53	38.33	-0.07	0.27
Leverage	45175	6.34	413.08	0.18	0.95
Foreign ownership	45368	0.03	0.17	0.00	0.00
Age	45367	13.66	7.17	5.00	24.00
Annual real total capital growth	42722	0.10	1.04	-0.39	0.75

Notes: This table provides summary statistics for the firm-level variables utilized in our empirical analysis. It exclusively includes data on loans issued in Hungarian forint to firms that do not have borrowings in other currencies. Panel A encompasses firms that received loans from at least two different banks in 2014. Panel B includes all firms that secured loans denominated in Hungarian forint within the same year.

statements, industry classifications, locations, and ages of all double-entry bookkeeping firms in Hungary. From this merged dataset, we derive a sample of 45,368 non-financial firms that had loans exclusively denominated in HUF and were active in 2014, among which 4,602 firms obtained loans from multiple banks. Table 3 presents summary statistics for key firm-level variables prior to the shock in 2014. On average, firms with multi-borrowing relationships are larger, generate higher revenue and employ more employees.

The final step of our data processing involves matching data from the Corporate Credit Registry with the MNB supervisory records on quarterly bank balance sheets. This matching process enables us to calculate the ratio of CHF corporate loans to total assets for each bank as of 2014:Q4. Our original sample included data from 105 financial intermediaries (banks and savings cooperatives) that had corporate loans in 2014. We excluded 16 banks due to mergers or closures in 2015-2017, and an additional 45 savings cooperatives that did not have at least 1% CHF assets in their balance sheets. Consequently, our analysis is limited to 23 commercial banks operating at the national level and 21 large local savings institutions, altogether accounting for 90% of the corporate loan volume in 2014:Q4. A.2 provides summary statistics for the primary bank-level variables used as controls in our analysis. It is important to note that we standardise all bank-level and firm-level variables in our regression analysis, although the tables with the summary statistics show values without standardisation.

4 Bank lending channel

4.1 BANK LENDING CHANNEL: MAIN RESULTS

Table 4 presents our baseline estimation results, examining the impact of CHF corporate loans on the credit supply to local currency borrowers following the CHF appreciation. Column (1) shows the results using the KM framework as specified in Equation 1, which provides an unbiased estimate of the bank lending channel coefficient (Khwaja and Mian (2008)). This framework incorporates firm fixed effects and is limited to firms with HUF denominated loans from multiple banks. The estimated coefficient of *CHFLoan* is negative and statistically significant at the 1% level, indicating a contractionary effect of unhedged CHF corporate loans on post-shock bank lending. Banks with higher pre-shock CHF corporate loans exhibited lower loan growth in the post-shock period compared to those with lower exposure, after controlling for firm-specific demand factors. Quantitatively, we find that when comparing lending to the same firm from two banks that differ by one standard deviation in CHF corporate loan exposure, the bank with higher exposure reduced its lending growth by approximately 10.23 percentage points.[21] This reduction corresponds to 11% of the standard deviation in the growth of multi-borrowing HUF loans, as indicated by the coefficient. As shown in Table 2 , although the growth of multi-borrowing HUF loans is highly volatile and sensitive, with a standard deviation of 0.93, the CHF corporate loan exposure can still explain a portion of this variation. This result supports our hypothesis that foreign currency mismatch risks are transmitted to bank balance sheets via CHF corporate loans, and subsequently spill over to local currency borrowers.

Table 4
Bank lending channel:main results

	(1)	(2)	(3)	(4)
	FE	OLS	OLS	FE
	gm(loan)	gm(loan)	gm(loan)	gm(loan)
CHFLoan	-0.110***	-0.070***	-0.046**	-0.114***
	(0.034)	(0.025)	(0.019)	(0.032)
Bank controls	Yes	Yes	Yes	Yes
R^2	0.394	0.015	0.336	0.401
Number of observations	10,052	10,052	52,790	10,052
Firm fixed effect	Yes	No	No	Yes
Control for household debt	No	No	No	Yes
Firm borrowing type	M	M	M&S	M

*Notes: This table presents the results of the loan-level analysis exploring the bank lending channel. The dependent variable, gm(loan), represents the normalised growth rate of loans granted by bank b to firm j from the pre-crisis period (2014:Q1–2014:Q4) to the post-crisis period (2015:Q1–2015:Q4). The primary independent variable is the ratio of unhedged CHF corporate loans to total assets (CHFLoan), measured at the end of 2014:Q4. Each column includes a set of bank controls including: (1) loan-to-deposit ratio, (2) dummy for low Tier 1 capital, (3) capital adequacy ratio, (4) loan loss provision-to-risk weighted assets ratio, (5) total deposits-to-liability ratio, (6) return on assets, (7) liquidity-to-risk weighted assets ratio, (8) interbank deposits-to-risk weighted assets ratio, (9) net CHF swap- and forwards-to-total assets ratio, (10) net CHF on-balance-position to-total asset ratio, and (11) percentage of loans firm j borrowed from bank b relative to the total credit extended to firm j by all banks. Models in Columns (1) and (4) are estimated using a sample of firms with multiple lending relationships and include firm fixed effects. Column (4) additionally controls for the impact of CHF household loans and loan conversion programme by including the CHF household loan-to-total assets ratio. The model in Column (3) includes both single- and multiple-relationship firms (Firm type: M& S). Standard errors are clustered at the bank level. Significance levels are denoted by ***, **, and * for 1%, 5%, and 10% levels, respectively.*

Column (2) of Table 4 presents our estimation results using a simple OLS model, wherein we exclude firm fixed effects and use the same sample to examine the impact of *CHFLoan* on the bank lending channel. The estimated coefficients retain the same

[21] All mismatch measures, controls, and the dependent variable are standardised. The quantitative magnitude is 0.11 times one standard deviation of the gm(loan), which is 0.93, resulting in a 10.23 percentage point change.

signs and level of significance as those in the fixed effect regression, but show declines in magnitude. This outcome indicates that the OLS estimation is likely to underestimates the impact of *CHFLoan* compared to the fixed effect estimation.

The results from both fixed effect and OLS estimations consistently demonstrate the statistically significant contractionary impact of pre-shock *CHFLoan* on the post-shock supply of HUF-denominated credit. These impacts extend beyond firms with multiple lending relationships. Column (3) of Table 4 presents the OLS estimation results for the entire sample of firms that borrowed in HUF from banks in 2014, including both single- and multiple- borrowers.[22] The coefficient of *CHFLoan* is statistically significant at the 5% level. Given the earlier discussion in Columns (1) and (2), which indicated that OLS results may underestimate the impacts, the OLS estimation for the full sample confirms that the bank lending channel has a considerable impact across the entire spectrum of firms.

Our results are not affected by the concern that banks have exposure to household CHF loans. The conversion programme, which fixed the exchange rate for CHF household loans, completely protected households from exchange rate shocks. However, the conversion could potentially influence the banks' credit supply, as it also affects bank balance sheets. To test this, in column (4) we control for the pre-shock Swiss franc household debt-to-assets ratio and find that adding this control does not alter our findings. The estimated coefficient of *CHFLoan* remains significant and retains the same magnitude as in Column (1).

In all regressions, we include net CHF assets and swap positions as controls to address potential on-balance-sheet and off-balance-sheet mismatch effects. This method allows us to consider the impacts on credit supply stemming from the revaluation of net CHF positions, both on- and off- balance sheet. In A.3, we present the estimated coefficients for all variables in the baseline specification (Column 1). We observe that the coefficients for both on- and off-balance sheet net CHF asset positions are insignificant. This result aligns with regulatory requirements that prevent banks from holding large net positions, necessitating hedges against the net position to manage direct exposure to currency mismatch risks effectively.

4.2 BANK LENDING CHANNEL: ROBUSTNESS TESTS

The results presented in Table 4 reveal a connection between the CHF corporate loan ratio and local currency lending by banks following the CHF shock. In this section, we address several concerns regarding the robustness of our baseline results.

ALTERNATIVE EXPLANATIONS

One potential concern with our identification strategy is that our baseline results could be partially influenced by market funding conditions, such as the availability of bonds or equity financing. Market funding conditions could change following the CHF appreciation, leading firms to issue more or less debt or equity, and adjust their loan demand accordingly. This change in demand may coincide with the pre-shock bank CHF corporate loan ratio and drive our baseline results. To address this concern, we exclude the top 10% of firms in size[23] in each sample and examine whether our baseline results change. We expect the coefficients to remain unchanged if our baseline results are not influenced by market funding, as only large firms in an emerging economy can access the bond or equity market[24]. The results, presented in Columns (1) and (2) of Table 5, show that the coefficients are almost the same as those in Table 4. This suggests that market funding conditions do not drive the main results in the baseline specification.

There was a policy event around the exchange rate shock that could also have had a negative impact on loan growth. Around the same time as the conversion programme, the Hungarian government reviewed the interest rates of all foreign currency loans and required banks to compensate household borrowers for the excess interest charged in the past years. [25] This policy can be viewed as interest rate "compensation" from the household's perspective, and it results in additional losses for bank operations, which could lead to a reduction in credit supply thereafter. To account for the impact of this specific policy, we included in our

[22] This sample includes only firms that borrowed exclusively in HUF and excludes those borrowing in both local and foreign currencies.

[23] Firm size is proxied by total assets in 2014.

[24] Although the percentage of firms that can access market funding is much less than 10%, we set the criterion as 10% since our sample of firms with multiple lending relationships are larger on average. During the analysed period, it was not prevalent among Hungarian corporations to issue bonds, apart from a few banks.

Table 5
Bank lending channel: robustness tests for alternative explanations

	(1) FE gm(loan)	(2) OLS gm(loan)	(3) FE gm(loan)	(4) OLS gm(loan)	(5) FE gm(loan)	(6) OLS gm(loan)
CHFLoan	-0.097***	-0.045*	-0.113***	-0.050***	-0.112***	-0.046*
	(0.033)	(0.025)	(0.036)	(0.017)	(0.032)	(0.025)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
Interest rate compensation	No	No	Yes	Yes	No	No
R^2	0.395	0.375	0.394	0.334	0.393	0.339
Number of observations	8,900	46,406	10,052	52,790	8,844	47,721
Firm fixed effect	Yes	No	Yes	No	Yes	No
Firm borrowing type	M	M&S	M	M&S	M	M&S
Exclude top 10% size firm	Yes	Yes	No	No	No	No
Exclude exporting firms	No	No	No	No	Yes	Yes

*Notes: This table presents robustness tests for alternative explanations. The dependent variable, gm(loan), represents the normalized growth rate of loans issued by bank b to firm j from the pre-crisis period (2014:Q1–2014:Q4) to the post-crisis period (2015:Q1–2015:Q4). The primary independent variable is the unhedged CHF corporate loan to total asset ratio, CHFLoan, measured at the end of 2014:Q4. Each column includes a comprehensive set of bank controls: (1) loan-to-deposit ratio, (2) dummy for low Tier 1 capital, (3) capital adequacy ratio, (4) loan loss provision-to-risk weighted assets ratio, (5) total deposits-to-liability ratio, (6) return on assets, (7) liquidity-to-risk weighted assets ratio, (8) interbank deposits-to-risk weighted assets ratio, (9) net CHF swap- and forwards-to-total assets ratio, (10) net CHF on-balance-position to-total asset ratio, and (11) CHF household loans to total asset ratio, (12) percentage of loans firm j borrowed from bank b relative to the total credit extended to firm j by all banks. Columns (1), (3), and (5) use models estimated on firms with multiple lending relationships and include firm fixed effects(Firm type: M). Columns (2), (4), and (6) expand the analysis to include both single- and multiple-relationship firms using OLS regression(Firm type: M& S). Standard errors are clustered at the bank level. Columns (1) and (2) exclude the largest firms (top 10% by size), Columns (3) and (4) include interest rate compensation as an additional control, and Columns (5) and (6) exclude firms with exporting activities. Significance levels are indicated by ***, **, and * for 1%, 5%, and 10% levels, respectively.*

baseline regression the interest rate compensation amount at the bank level calculated by the MNB. The addition of this control only strengthens the estimated coefficient of *CHFLoan* somewhat, as shown in Columns (3) and (4) in Table 5, thereby mitigating the confounding effect of this policy.

One additional concern is that our analysis could be biased due to the exchange rate shock potentially influencing international trade conditions. Even though the firms in our sample borrow exclusively in local currency, if they are involved in exporting to Switzerland, the exchange rate shock could influence their real operations and debt decisions. However, this influence should be controlled by the firm fixed effects. To more formally account for this influence, especially for our sample with single-borrowing firms where we cannot add firm fixed effects, we conduct an additional analysis in Columns (5) and (6). We exclude all firms that have export income, which accounts for 13% of the firms in our sample. The results show that our findings remain largely unchanged, thus rejecting the potential influence of trade.

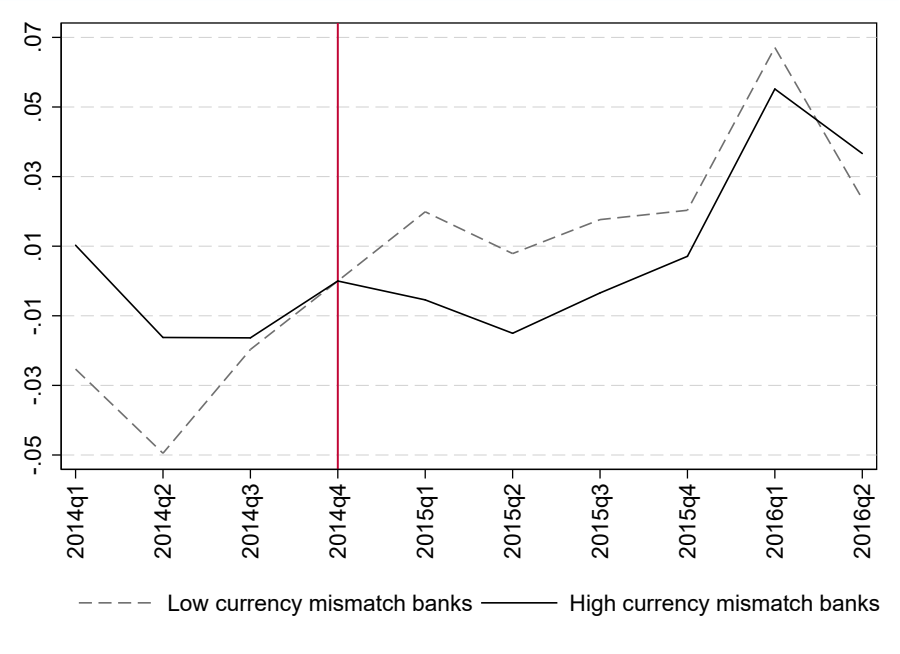
PARALLEL TREND ASSUMPTION

As our regressions specification is the difference-in-difference (DID) method, a natural concern regarding this identification strategy is the potential influence of pre-existing trends that could drive differences in post-shock lending growth between banks with high versus low CHF exposure to risks from CHF corporate loans. To address this concern, we verify the presence of

[25] Gyongyosi and Verner (2024) specifically examines the impact of this policy event. Here, we provide some background: In 2014, the Supreme Court ruled that two aspects of foreign currency loans were unfair: (1) banks often charged foreign currency borrowers an exchange rate spread when converting instalments on foreign currency loans into domestic currency; and (2) banks unilaterally altered loan contract terms by introducing additional fees. Subsequently, the government passed a law requiring banks to compensate borrowers for excess payments resulting from these unfair terms. These excess payments were treated as prepayments, thereby providing debt relief. This debt relief was initially applied to repay penalties and other fees, with any remaining amount used for principal reduction. Households which had already repaid their loans received compensation in cash.

parallel trends at the aggregate level. Following the method proposed by Bottero et al. (2020), we semi-parametrically classify banks in our final sample into "High" and "Low" groups based on their conditional exposure to CHF corporate loan risk in the last quarter of 2014. These groups are classified as "treatment" and "control" groups in our analysis[26]. We then aggregate the loan volumes denominated in HUF provided by banks for the High and Low groups. Finally, we plot the logarithmic values of these two time series, normalising each on the y-axis to 0 in 2014:Q4.

Figure 4
Bank lending channel at the aggregate level



Notes: This figure presents a semi-parametric analysis of the bank lending channel, comparing the lending behaviour of banks based on their unhedged CHF corporate loan-to-total assets ratio. To classify the banks, we conduct a cross-sectional regression of the CHF corporate loan ratio on the same bank characteristic controls used in our baseline regression for the bank lending channel, all measured at the end of 2014. Banks with residuals above the median were placed in the "High CHF loan" group, while those with residuals below the median were categorised into the "Low CHF loan" group. The y-axis displays the logarithmic growth rate of total bank lending in Hungarian forint relative to the fourth quarter of 2014.

Figure 4 illustrates the bank lending channel by comparing lending to firms from banks categorized by their exposure to risks from CHF corporate loans. The y-axis displays the logarithmic growth rates of nominal lending for each quarter relative to the baseline in 2014:Q4, including HUF loans to both single-borrowing and multi-borrowing firms. The aggregate bank lending trends depicted in Figure 4 substantiate our identification strategy. The plot reveals that the divergence in lending trends immediately following the appreciation of the CHF cannot be solely ascribed to pre-existing differences in trends.

To provide more formal quantitative support for the no difference in trend prior to the shock, we follow the approach of Schnabl (2012) to estimate a placebo regression using data before the CHF appreciation shock. We set a placebo cutoff one year before the CHF shock. The specification of the placebo test is the same as our baseline regression for loan-level analysis. All variables are constructed using data from 2012:Q1 to 2013:Q4, with the exception of the main independent variable *CHFLoan* and the bank on- and off-balance sheet Swiss franc asset positions, which still use data from 2014:Q4. Table 6 presents the results of the placebo test. We observe no statistically significant coefficients of pre-shock *CHFLoan* on lending growth from two years ago. This result indicates no distinction in lending growth trends for banks with different exposures to risk from CHF corporate loans before the shock.

[26] To classify the banks, we conduct a cross-sectional regression of the CHF corporate loan ratio on the same bank characteristic controls used in our analysis, all measured in 2014:Q4. Based on the estimated residuals from this regression, we assign banks to the "High CHF loan" group if their residuals are above the median, and to the "Low CHF loan" group if their residuals are below the median. This classification allows us to isolate banks based on the cross-sectional variation of their CHF loan ratios, independent of bank-specific characteristics.

Table 6
The bank lending channel: a placebo test

	(1)	(2)
	FE	OLS
	gm(loan)	gm(loan)
CHFLoan	0.029	0.031
	(0.051)	(0.040)
Bank controls	Yes	Yes
R^2	0.428	0.014
Number of observations	9,154	9,167
Firm fixed effect	Yes	No
Firm borrowing type	M	M

*Notes: The regressions in this table perform a placebo test to assess the impact of the CHF loan ratio on bank lending two years prior to the CHF appreciation. The placebo cutoff was set two years before the shock. The regression model follows the specification of Equation 1, with firm fixed effects in Column (1) and without in Column (2). The dependent variable, gm(loan), measures the normalised growth rate of loans issued by bank b to firm j from the 'pre-shock' period (2012:Q1–2012:Q4) to the subsequent year (2013:Q1–2013:Q4). We implement the same bank controls in each column as those used in the baseline regression, measured in 2012. The independent variable CHFLoan and bank on- and off-balance sheet CHF asset positions are measured as of 2014:Q4. The analysis is confined to firms that borrow from multiple banks(firm type: M). Standard errors are clustered at the bank level. Significance levels are denoted by *** for 1%, ** for 5%, and * for 10%.*

ALTERNATIVE OUTCOME VARIABLES

To ensure the robustness of our results, we conduct several additional tests using alternative outcome variables. Table 7 presents the results of these tests. Initially, we analyse the relationship between the "exit rate" of a bank-firm lending relationship and the bank CHF corporate loan ratio, depicted in Columns (1) and (2). The "exit" dummy variable is set to one if a credit relationship established before the shock is terminated in the post-shock period, thereby measuring the extensive margin effect of the bank lending channel. In the fixed effects (FE) model, we find that banks with greater exposure to risks from CHF corporate loans are more likely to terminate credit relationships. Specifically, a one-standard-deviation increase in exposure is associated with a 4.6% higher probability of exiting compared to banks with lower exposure. However, this effect was not significant in the ordinary least squares (OLS) estimation that included all firms[27].

We subsequently examined effects along the intensive margin in Columns (3) and (4), focusing on the pure change in bank lending without the termination effect. The dependent variable is the simple log growth rate of credit granted by bank b to firm j between the pre-shock average (2014:Q1–2014:Q4) and the post-shock average (2015:Q1–2015:Q4)[28]. We find that a higher CHF corporate loan ratio is significantly associated with a higher intensive margin effect on the bank lending channel. This result is consistently found in both the fixed effects (FE) model estimated with samples of firms having multiple lending relationships and the ordinary least squares (OLS) estimation using the full sample. Taken together, these results, particularly the unbiased FE estimation results presented in Columns (1) and (3), suggest that CHF corporate loans significantly affect credit supply through both intensive and extensive margins.

ALTERNATIVE SPECIFICATION

We conduct a robustness check of our main findings using an alternative model that preserves information which might be lost through averaging, following the approach described by Verner and Gyöngyösi (2020). Unlike methods that aggregate loans into pre-shock and post-shock averages, the alternative specification employs the logarithm of loan quantities as the

[27] This lack of significance in the OLS model could be due to its potential bias compared to the FE model, possibly underestimating the impact.

[28] In this measure of the log growth rate, we omit observations that have a zero value to ensure that we capture only the intensive margin effect.

Table 7
Bank lending channel: robustness tests for alternative outcome variables

	(1)	(2)	(3)	(4)
	FE	OLS	FE	OLS
	Exit	Exit	g(loan)	g(loan)
CHFLoan	0.046***	0.006	-0.075**	-0.118***
	(0.009)	(0.008)	(0.032)	(0.041)
Bank Controls	Yes	Yes	Yes	Yes
R^2	0.472	0.008	0.461	0.026
Number of observations	10,052	52,790	6,602	39,328
Firm fixed effect	Yes	No	Yes	No
Firm borrowing type	M	M&S	M	M&S

Notes: This table presents several robustness tests using alternative outcome variables. The outcome variable is the "Exit" dummy in Columns (1) and (2), and the simple log growth rate in Columns (3) and (4). The primary independent variable is the unhedged CHF corporate loan to total assets ratio (CHFLoan), measured at the end of 2014:Q4. The regression model follows the specification of Equation 1. We implement the same bank controls in each column as those used in the baseline regression. Columns (1) and (3) apply models to firms with multiple lending relationships and include firm fixed effects(firm type: M). Columns (2) and (4) expand the analysis to include both single- and multiple-relationship firms using OLS regression(firm type: M&S). Standard errors are clustered at the bank level. Significance levels are denoted by $***$ for 1%, $**$ for 5%, and $*$ for 10%.

dependent variable. This approach is designed to directly capture quarterly fluctuations in loan volumes during the period of CHF appreciation. The regression equation for this alternative model is:

$$\begin{aligned}\text{log(loan)}_{b,j,t} =& \beta_0 + \beta_1 \text{CHFLoan}_{b,2014Q4} \times \text{Post} + \Gamma X_{b,2014} + \Pi V_{j,2014} + \rho_j + \\ & \rho_j^{industry} + \rho_j^{region} + \rho^{time} + \epsilon_{b,j,t}\end{aligned}$$

In this model, the dependent variable is the logarithm of the loan volume between bank b and firm j for each quarter t in period of 2014-2015. The primary independent variables are the post-shock dummy and an interaction term between the post-shock dummy indicator and *CHFLoan*. To control for firm-specific credit demand changes, we include firm fixed effects and a set of control variables encompassing bank characteristics $X_{j,2014}$, firm characteristics $V_{b,2014}$, as well as industry, time, and regional fixed effects[29].

Table 8 presents the estimation results[30]. Columns (1) and (2) feature estimates using firms with multiple forint borrowing relationships, while Columns (3) and (4) extend the analysis to the full sample, which includes firms with both single and multiple borrowing relationship. Columns (1) and (3) incorporate only firm fixed effects and bank controls, whereas Columns (2) and (4) include a more comprehensive set of controls. All coefficients of the interaction term *CHFLoan* $\times$ *Post* are significantly negative, supporting the same economic insight as our baseline regression: banks with high exposure reduce credit supply in the post-shock period. This specification further substantiates our baseline findings, demonstrating that our results are robust and not merely the artifact of using the average growth rate as a measure for credit supply variation.

[29] The firm-level control variables are consistent with those used in firm-level analysis in subsequent sections. We always include *CHFLoan* and *Post* as control variables.

[30] In this test for the alternative specification, all regressions include the control variable for the pre-shock CHF household-to-asset ratio. This is for the same reason as in column (4) of Table 4.

Table 8
Bank lending channel: quarterly difference-in-difference

	(1)	(2)	(3)	(4)
	log(loan)	log(loan)	log(loan)	log(loan)
Post	0.286***	0.359***	0.142***	0.180***
	(0.015)	(0.022)	(0.005)	(0.006)
CHFLoan *Post	-1.159**	-1.197**	-0.819***	-0.875***
	(0.502)	(0.505)	(0.159)	(0.160)
Bank controls	Yes	Yes	Yes	Yes
Firm control	No	Yes	No	Yes
R^2	0.680	0.680	0.887	0.884
Number of observations	63,641	63,002	325,576	320,049
Firm Fixed effect	Yes	Yes	Yes	Yes
Industry Fixed effect	No	Yes	No	Yes
Region Fixed effect	No	Yes	No	Yes
Time Fixed effect	No	Yes	No	Yes
Firm borrowing type	M	M	M&S	M&S

*Notes: This table presents the robustness test for alternative specifications assessing quarterly variations in bank lending. The dependent variable is the logarithm of the loan volume between bank b and firm j in quarter t. The primary independent variable is the unhedged CHF loan ratio interacted with a post-shock dummy. We implement the same bank controls in each column as those used in the baseline regression, plus the CHF household debt-to-assets ratio, with all variables measured at the end of 2014. Columns (2) and (4) further incorporate a set of firm controls, along with industry, region, and time fixed effects. Columns (1) and (2) focus on firms with multi-borrowing relationships(firm type: M), while Columns (3) and (4) broaden the analysis to encompass both single- and multi-borrowing firms(firm type: M & S). Standard errors are clustered at the bank level. Significance levels are indicated by *** for 1%, ** for 5%, and * for 10%.*

4.3 BANK LENDING CHANNEL: TRANSMISSION MECHANISM

We study how the bank lending channel transmits exchange rate shocks to local currency borrowers. Our hypothesis posits that banks with extensive CHF lending to unhedged firms incur increased losses on credit following the CHF appreciation. These credit losses arise due to a higher default probability and prolonged payment delays among these borrowers. Consequently, banks are compelled to increase their loan loss provisions, which subsequently reduces their liquidity and capital. The resultant liquidity shortage curtails the banks' ability to extend new loans, while diminished capital levels compel the banks to reduce the size of their loan portfolio to meet capital adequacy requirements.

We first investigate whether banks with a greater volume of unhedged CHF corporate loans experience an increased incidence of CHF credit losses. We develop a new variable from the credit registry data to quantify each bank's exposure to credit losses from CHF corporate loans. This variable is defined as the ratio of non-performing CHF corporate loans to total corporate loans, with all loans converted to the local currency value based on the actual quarter-end exchange rate. Default is defined as a payment delay exceeding 90 days. We then analyse changes in the CHF non-performing loan ratio relative to banks' pre-shock exposure to unhedged CHF corporate loans. Our analysis utilises two regression methods: first, we perform bank-level regressions, each weighted by the respective bank's total assets; second, following Beck et al. (2022), we conduct loan-level regressions that retain the firm fixed effect specification from our earlier loan-level analysis but apply a bank-level dependent variable, effectively making this approach analogous to a loan number weighted regression.

Table 9 presents the regression results. Columns (1) to (4) present changes in the CHF non-performing loan (NPL) ratio from the fourth quarter of 2014 to each of the subsequent four quarters. The coefficients are statistically significant and positive, indicating that banks with a higher CHF corporate loans ratio experience increased CHF credit losses.[31] Two reasons underlie

Table 9
Link between CHF corporate loan ratio and the change in non-performing loan ratio

	(1) ΔNPL_{Q1}^{CHF}	(2) ΔNPL_{Q2}^{CHF}	(3) ΔNPL_{Q3}^{CHF}	(4) ΔNPL_{Q4}^{CHF}
Panel A: WLS regression				
CHFLoan	0.475***	0.843***	0.969***	0.718***
	(0.047)	(0.051)	(0.052)	(0.062)
R-squared	0.900	0.933	0.949	0.880
Number of observations	44	44	44	44
Panel B: FE regression				
CHFLoan	0.443***	0.809***	0.936***	0.742***
	(0.035)	(0.040)	(0.037)	(0.020)
Firm fixed effect	Yes	Yes	Yes	Yes
R-squared	0.899	0.933	0.959	0.935
Number of observations	10,052	10,052	10,052	10,052
Bank controls	Yes	Yes	Yes	Yes
Interest rate Compensation	Yes	Yes	Yes	Yes
Firm borrowing type	M	M	M	M

*Notes: This table presents results testing the direct relationship between the unhedged CHF corporate loan ratio and subsequent changes in the CHF non-performing loan (NPL) ratio. The dependent variable, the change in the CHF NPL ratio, is analyzed from 2014:Q4 to each subsequent quarter in 2015 in Columns (1) to (4). The CHF NPL ratio, defined as the ratio of non-performing CHF loans (loans with repayments late by more than 90 days) to total loans, is calculated using the quarter-end exchange rate to convert all loans to the local currency. We scale the ratio by 100 times, so the coefficients represent changes in percentage points. The primary independent variable is the unhedged CHF corporate loan ratio, measured at the end of 2014. We implement the same bank controls in each column as those used in the baseline regression. Bank asset-weighted OLS regressions run on bank level data are included in Panel A, while Panel B incorporates firm fixed effects regressions run on loan-level data, consistent with our loan-level bank lending analysis. Standard errors are clustered at the bank level. Significance levels are denoted as follows: *** for 1%, ** for 5%, and * for 10%.*

these results. The first is that banks with higher volumes of CHF corporate loans may already exhibit a higher pre-shock CHF NPL to total loans ratio. Following the CHF appreciation, the value of these NPLs increases when converted to the local currency, thereby further elevating the CHF NPL ratio. However, this alone does not fully explain the observed patterns as the coefficients are notably larger for quarters following the first quarter of 2015, despite exchange rates stabilising post-shock. The higher coefficients after the first quarter suggest a second factor: the occurrence of new defaults. For banks with significant exposure to unhedged firms, CHF non-performing loans continue to rise sharply, even without further exchange rate fluctuations. Both factors have profound implications for bank operations. The upward revaluation of loans that defaulted prior to the shock necessitates increased calculations of asset risk, which further raises loan provisions. Additionally, new defaults occurring post-shock directly impact the banks' cash flows, compelling them to increase loan provisions.

In the Appendix, we present additional evidence demonstrating that banks with a substantial portfolio of CHF corporate loans experience increased CHF credit losses. A.5 presents regression results using changes in the ratio of CHF loans overdue for 30 to 90 days or 30 to 180 days during the first two quarters of 2015 as the dependent variable. These measures captures new defaults that occurred in this period. The significant positive coefficient provides direct evidence that higher exposure to CHF corporate loans during this period led to increased credit losses from these new defaults. This finding also corroborates that the results depicted in Table 9 are not solely attributable to exchange rate appreciation. Specifically, the measurement of loans overdue for 30 to 90 days (Table 18) in the first two quarters of 2015 reflects defaults occurring within this period and is not

[31] In A.4, we also present the results using a 30-day late payment default criterion as a robustness check, with the qualitative findings remaining consistent.

influenced by prior defaults. Loans overdue for 30 to 90 days in 2014:Q4 are excluded from the measurements for 2015:Q1 and 2015:Q2. As a result, the revaluation effect due to exchange rate appreciation in 2014:Q4 does not carry over to the following quarters, allowing the regression to focus solely on new defaults. Furthermore, A.6 provides summary statistics of firms' late payments across different currencies. The data indicates a notable increase in the average number of days of late payments for CHF loans in 2015 compared to 2014, especially when contrasted with HUF and EUR loans.

Increasing credit losses from CHF corporate loans reduce profitability and the risk-weighted capital ratio from an accounting perspective, thereby limiting the bank's ability to issue new loans[32]. We further explore the capital channel by examining the relationship between changes in banks' capital adequacy ratios (CAR) and their exposure to CHF corporate loans. We employ the same regression specification as used in the previous analysis with the CHF NPL ratio, apart from that the dependent variable is the change in the CAR. Table 10 presents the results, illustrating the direct link between *CHFLoan* and changes in the capital adequacy ratio. Columns (1) and (3) show that *CHFLoan* is significantly and negatively correlated with changes in the capital adequacy ratio from the fourth quarter of 2014 to the first quarter of 2015. This effect persists over time; Columns (2) and (4) demonstrate that the coefficients are also negative over a longer term, from the fourth quarter of 2014 to the second quarter of 2015. These findings provide direct evidence that bank capital, a critical determinant of future credit supply, can be impacted by pre-shock exposure to CHF corporate loans.

Table 10
Link between mismatches and changes in capital adequacy ratios

	(1)	(2)	(3)	(4)
	WLS	WLS	FE	FE
	ΔCAR_{2015Q1}	ΔCAR_{2015Q2}	ΔCAR_{2015Q1}	ΔCAR_{2015Q2}
CHFLoan	-0.370*	-0.165	-0.452***	-0.355*
	(0.181)	(0.203)	(0.146)	(0.210)
Bank controls	Yes	Yes	Yes	Yes
Interest rate Compensation	Yes	Yes	Yes	Yes
R^2	0.862	0.904	0.949	0.950
Number of observations	44	44	10,052	10,052
Firm fixed effect	No	No	Yes	Yes

*Notes: This table presents the direct relationship between the unhedged CHF corporate loan ratio and subsequent changes in the capital adequacy ratio. The dependent variable is the change in the capital adequacy ratio from the fourth quarter of 2014 to one quarter later or one year later. The primary independent variable is the unhedged CHF corporate loan ratio, measured at the end of 2014. We implement the same bank controls in each column as those used in the baseline regression. Columns (1) and (3) examine changes in the capital adequacy ratio from 2014:Q4 to the 2015:Q1, while Columns (2) and (4) assess changes from the 2014:Q4 to 2015:Q2. Columns (1) and (2) utilize bank asset-weighted least squares with bank-level data, whereas Columns (3) and (4) apply firm fixed effects consistent with our loan-level bank lending analysis, using loan-level data. Significance levels are denoted by *** for 1%, ** for 5%, and * for 10%.*

In summary, our findings are consistent with those of Galaasen et al. (2020), indicating that an increase in credit risk for certain firms can degrade the quality of a bank's portfolio, which subsequently affects lending to other firms without experiencing credit deterioration. The capital channel is pivotal in this process. Similarly, in our case, banks find it difficult to hedge against a sudden increase in credit risk because it is caused by an exogenous and unpredictable exchange rate shock. Since this risk emerges after loans are issued, there are limited tools available to mitigate it. In a frictionless world, banks could simply raise new capital to offset the risk and maintain their previous level of credit supply. However, in reality, this process is slow and costly, making it difficult for banks to raise capital quickly. As a result, they must adjust their lending to manage balance sheet size and maintain capital adequacy. It is also important to note that our analysis of NPLs and capital is based on realized changes, meaning it reflects ex-post outcomes. In anticipation of a rise in NPLs, a rational manager would adjust the lending portfolio

[32] Provisions appear as an item on the liability side as well as a cost entry on the income statement. When a borrower misses a payment, it incurs a cost and increases liabilities, reducing equity. Conversely, when the borrower makes up the missed payment and resumes regular payments, the reduction in provisions is recorded as a profit and a decrease in liabilities, thereby increasing equity.

immediately to mitigate the negative effects of defaults after the exchange rate shock. This adjustment does not necessarily require actual defaults to occur; it is sufficient for banks to expect an increase in credit risk following the shock.

Following the approach of Bottero et al. (2020) and Khwaja and Mian (2008), we further explore transmission channels by employing regression analysis with interaction terms. Building on our previous discussion, we specifically investigate how weakened capital positions or liquidity conditions exacerbate the bank lending channel. We measure liquidity conditions using the loan-to-deposit ratio as a continuous variable, where a higher ratio indicates poorer liquidity. For capital conditions, we use a dummy variable set to one when the Tier 1 capital ratio is considered low[33]. Table 11 presents our findings[34]. Examining one interaction at a time, we find evidence supporting both channels. Specifically, poorer liquidity conditions statistically significant exacerbate the contraction effects of CHF corporate loans on credit supply, as shown in Column (1). Here, the negative and significant coefficient suggests that the contraction effect intensifies with an increase in the loan-to-deposit ratio. Furthermore, in Column (2), we observe a much stronger contraction effect of *CHFLoan* on firms borrowing from banks with lower capital ratios, while the effect is not significant for firms borrowing from banks with higher capital ratios. Together, these findings from regression with interaction terms confirm that both bank liquidity and capital are crucial in determining the impact of the bank lending channel on local currency borrowers.

[33] To ensure balance in each group, the dummy is assigned a value of one if the Tier 1 capital ratio is below the median value, calculated based on the total number of loans. From the entire set of 10,052 observations, we calculate the median bank capital ratio at the loan level, dividing the data into two subgroups, each comprising 5,026 observations. This division implies that half the loans are sourced from banks with high capital, with the remaining half from banks with lower capital.

[34] While the tables display only the interaction terms, every regression also includes the individual variables in the interaction terms.

Table 11
Channels of transmission

	(1) FE gm(loan)	(2) FE gm(loan)
$CHFLoan$	-0.143***	0.005
	(0.0177)	(0.045)
CHFLoan[f] interacted with loan to deposit ratio	-0.500***	
	(0.124)	
Low Tier one capital dummy		-0.202***
		(0.052)
Bank controls	Yes	Yes
Interest rate compensation	Yes	Yes
R^2	0.404	0.403
Number of observations	10,052	10,052
Firm Fixed effect	Yes	Yes
Bank type	Bank	Bank
Firm borrowing type	M	M

*Notes: This table presents the transmission channels of the bank lending channel using regression analysis with interaction terms. We analyse the effects of weakened capital positions and liquidity conditions on bank lending. Liquidity is assessed through the loan-to-deposit ratio, with a higher ratio indicating lower liquidity. Capital conditions are measured using a dummy variable set to one when the Tier 1 capital ratio is considered low. The dependent variable, the normalised loan growth rate gm(loan), compares loans granted by bank b to firm j from the pre-crisis period (2014:Q1 to 2014:Q4) to the post-crisis period (2015:Q1 to 2015:Q4). We implement the same bank controls in each column as those used in the baseline regression. The model is estimated within-firm for samples with multiple borrowing relationships(firm type:M) and includes firm fixed effects. Standard errors are clustered at the bank level. Significance levels are indicated by *** for 1%, ** for 5%, and * for 10%.*

5 Firm level impact of the bank lending channel

Our loan-level analysis provides evidence of the spillover of currency risk from CHF corporate loans to local currency bank lending. However, loan-level results may not fully capture the net firm-level effects of the bank lending channel. As noted by Jiménez et al. (2020), firms impacted by credit reductions from some banks might establish new borrowing relationships with other banks to compensate for the lost credit. In this section, we explore the impact of credit contraction at the firm level, focusing on two main questions: (1) Can firms mitigate bank-specific credit supply contractions by establishing new borrowing relationships with banks holding fewer CHF corporate loans? (2) How do changes in loan supply affect firm operations?

The firm-level analysis incorporates both samples of multiple-borrowing firms and the full sample. The regression specification, detailed in Equation 3, employs the loan size-weighted average of the bank-level CHF corporate loan ratio for each borrower, denoted as *CHFLoan*^{AVE}, as the independent variable. As discussed in Section 3, analysing multi-borrowing firms allows us to incorporate the estimated firm fixed effect $\hat{\rho}_j$ from the loan-level analysis, thereby controlling for firm-specific demand factors. To address the first research question, we use the growth rate of total bank credit for each firm as the dependent variable. The coefficients of *CHFLoan*^{AVE} provide insights into the extent of neutralisation of the credit supply shock. A coefficient of zero would suggest that firms can fully compensate for bank-specific credit supply contractions by securing additional credit from less affected banks. Conversely, a negative coefficient indicates that contractionary credit supply intensifies the total borrowing constraints faced by firms.

Table 12
Firm level impact: total bank credit

	(1)	(2)
	OLS	OLS
	gm(total loan)	gm(total loan)
CHFLoan^{AVE}	-0.122***	-0.012**
	(0.009)	(0.005)
Bank controls	Yes	Yes
Firm controls	Yes	Yes
Fitted FE	Yes	No
R-squared	0.595	0.549
Number of observations	4,510	44,356
Firm borrowing type	M	M&S
Region × industry	Yes	Yes

*Notes: This table presents the firm-level impact of the bank lending channel. The dependent variable, gm(total loan), measures the normalized growth rate of total bank credit extended to firm j from the pre-crisis period (2014:Q1 to 2014:Q4) to the post-crisis period (2015:Q1 to 2015:Q4). All firms borrow exclusively in Hungarian forint. The independent variable is the loan size-weighted average of the CHF corporate loan ratio for each borrower. The regression model includes a variety of control variables: weighted average bank controls, firm-specific controls, fitted firm fixed effects, and region × industry fixed effects. Standard errors are clustered at the regional level. Significance levels are denoted by *** for 1%, ** for 5%, and * for 10%.*

Table 12 presents results from the firm-level total bank credit regressions. The analysis reveals a negative and statistically significant effect on credit supply at the firm level, indicating that firms were unable to fully compensate for changes in credit supply by borrowing from banks with lower mismatches. Specifically, for the sample of firms with multi-borrowing relationships,

a one-standard deviation increase in the indirect exposure *CHFLoan*^{AVE} predicts approximately a 12% decrease in the growth rate of total firm credit. The effect is also negative not only for firms with multiple bank relationships but also across the entire sample of firms (Column 2), suggesting that the inability to neutralize credit friction was widespread, not just confined to firms with multiple banking relationships. Although the OLS specification may still be subject to bias due to the absence of firm fixed effects, the results are nevertheless insightful. Echoing findings by Khwaja and Mian (2008), our loan-level analysis indicates that OLS tends to underestimate the impact of the bank lending channel compared to fixed-effect estimates, implying a positive correlation between our measurement of the CHF corporate loan ratio and unobservable demand effects. Therefore, our estimated coefficient at the firm level remains informative, as even potential underestimations are statistically significant and negative.

In light of the finding that the bank lending channel affects the total borrowing of firms, we further examine the consequences of credit supply contraction on corporate behaviour. We have two main objectives. The first is to quantify the contribution of bank credit supply shocks to the aggregate change in long-term capital accumulation over the next two years. The second objective is to investigate whether credit supply shocks affected the probability of a firm's liquidation in the subsequent year. Previous literature has emphasised that smaller firms may be more vulnerable to negative credit shocks (Bernanke et al. (1994)). We use firm income (log revenue) as a proxy for firm size and interact it with *CHFLoan*^{AVE} to test the heterogeneity of corporate behaviour.

Table 13 presents the results, organised into two panels: Panel A displays results for multi-borrowing firms, while Panel B encompasses all firms. Columns (1) and (2) report results from Equation 3, with the dependent variable being the two-year total capital growth rates of firms. Analysis of multi-borrowing firms reveals that, on average, these firms are not significantly affected by credit supply contraction in terms of capital growth rates (Panel A). However, when examining the full sample, which includes a mix of firms with both multiple and single borrowing relationships, the impact of credit supply contraction becomes statistically significant on firm investment. In Panel B, Column (2) shows that the coefficient decreases with an increase in firm size, suggesting that larger size can partly mitigate the negative effects, indicating size heterogeneity in the impact of credit frictions on the real economy. This finding also provides a possible explanation for the insignificant real effects observed in Panel A: multi-borrowing firms are typically larger, more profitable, and have lower leverage (as shown in Table 3), thus are likely to enjoy better liquidity conditions to withstand credit supply contractions. Conversely, in the full sample, which generally includes smaller firms, the impact of credit supply contraction is more pronounced.

Next, we predict a firm's likelihood of liquidation following the CHF appreciation using *CHFLoan*^{AVE}. We conduct nonlinear probability regressions on a panel that includes both surviving and exiting firms over the one-year period following the shock. The dependent variable is set to one if the firm exited in 2015, and zero otherwise.[35] The results of these probit regressions are shown in Columns (3) and (4), revealing a pattern similar to the investment analysis. On average, the indirect exposure *CHFLoan*^{AVE} affects the likelihood of liquidation only in the sample that includes all firms (Panel B), not in the sample exclusively comprising multi-borrowing firms (Panel A). The significant coefficient of indirect exposure *CHFLoan*^{AVE} in Column (3), Panel B, demonstrates that an increase in exposure leads to a heightened possibility of liquidation in the full sample. Although the coefficients in the interaction terms are not significant, the negative coefficients in column (4), Panel B suggest that larger firms in the full sample may mitigate this effect. This observation supports the notion that financial frictions primarily affect the operations of smaller firms. Therefore, large multi-borrowing firms remain relatively stable after the credit supply contraction in our empirical analysis. These findings are particularly salient for Hungary's economy, predominantly comprised of small businesses. Fluctuations in credit supply may cause significant output variations within these firms, and their widespread presence across the country could amplify economic volatility, potentially leading to broader economic fluctuations within Hungary.

[35] Our information about liquidation is based on whether a firm has submitted a tax form. In Hungary, a firm may fail to submit tax forms for a few years, which could indicate either liquidation or a temporary cessation of operations. Both scenarios are treated as liquidation for this analysis.

Table 13
Firm-level total capital growth rate

	(1) OLS g(capital 2y)	(2) OLS g(capital 2y)	(3) Probit Liquidation 1y	(4) Probit Liquidation 1y
Panel A: Multi-borrowing firms				
$CHFLoan^{AVE}$	-0.016	0.007	0.011	0.109
	(0.014)	(0.076)	(0.034)	(0.143)
$CHFLoan^{AVE}$ × log revenue		-0.002		-0.009
		(0.006)		(0.011)
Fitted FE	Yes	Yes	Yes	Yes
R-squared	0.032	0.039	0.024	0.025
Number of observations	4,049	4,021	4,378	4,339
Firm borrowing type	M	M	M	M
Panel B: Multi- and single-borrowing firms				
$CHFLoan^{AVE}$	-0.018**	-0.202***	0.030**	0.089**
	(0.008)	(0.030)	(0.012)	(0.043)
$CHFLoan^{AVE}$ × log revenue		0.016***		-0.005
		(0.002)		(0.003)
Fitted FE	No	No	No	No
R-squared	0.053	0.061	0.012	0.010
Number of observations	39,455	38,786	43,021	42,146
Bank controls	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes
Region × Industry	Yes	Yes	Yes	Yes
Firm borrowing type	M&S	M&S	M&S	M&S

*Notes: This table illustrates the real effects of credit supply shocks at the firm level. The outcome variables include the logarithmic growth rate of two-year total capital and a one-year firm liquidation dummy. Panel A presents results for firms with multiple borrowing relationships, while Panel B extends the analysis to encompass all firms. The independent variable is the loan size-weighted average of the CHF corporate loan ratio for each borrower. The regression model includes control variables such as weighted average bank controls, firm-specific controls, fitted firm fixed effects, and region × industry fixed effects. Columns (2) and (4) additionally incorporate the interaction term with log revenue as a control variable to account for firm size effects. Standard errors are clustered at the regional level. Significance levels are denoted by *** for 1%, ** for 5%, and * for 10%.*

6 Conclusion

Using comprehensive loan, firm, and bank data from Hungary, this study reveals the mechanisms through which the exchange rate shock is transmitted to local firms via the bank lending channel. Unlike previous research that primarily focuses on the direct effects of indebtedness among foreign currency borrowers, our analysis extends the understanding by illustrating the broader spillover effects of foreign currency loan risks on local currency borrowers. Specifically, following the appreciation of the Swiss franc, there was a significant increase in the debt burden of CHF borrowers, which led to elevated default rates among these borrowers. The resultant increase in defaults caused statstically significant credit losses for banks, compelling them to curtail their lending activities to local currency borrowers. Our empirical findings indicate that banks with a standard deviation higher in CHF corporate loans curtailed their post-shock local currency credit growth by more than 10% after adjusting for firm demand[36].

Two additional findings stem from our further investigation. First, our analysis underscores the critical roles of capital and liquidity in the banking system. We observed that banks characterized by weaker capital and liquidity positions were more likely to exacerbate reductions in local currency lending following the exchange rate shock. Second, our results confirm that the bank lending channel influenced by exchange rate shocks extends its impact to firm operations, particularly affecting small firms. These firms, often more sensitive to changes in credit supply, faced more pronounced operational challenges under tightened lending conditions.

We enhance understanding of how exchange rate shocks propagate through the banking sector, affecting the broader economy and impacting firms that are not directly exposed to foreign currency risks. While our research offers significant insights into the micro-level effects of exchange rate shocks on the local currency bank lending channel, it does not examine the effects on bank lending at the aggregate level, such as the impact on regional economies. This omission highlights a significant area for future research, suggesting an empirical exploration of the macroeconomic implications of such shocks.

Our findings carry important policy implications. They support the need for policies that limit bank exposures to exchange rate risks from foreign currency lending, going beyond merely controlling the banks' direct currency mismatch. Indeed, after the Great Recession financial supervisory authorities monitor a wide range of indicators which help to judge the accumulation financial risks, and warrant prompt reaction if necessary. In the particular case of Hungary the conversion of foreign currency household loans was administered in November 2014. Regarding the foreign currency firm loans the MNB launched several programmes before the 2015 shock that helped firms –mainly small- and medium-sized enterprises– to convert their foreign currency liabilities to domestic ones. Despite the success of these programmes, firms did not always fully exploit these facilities.

[36] A back-of-the-envelope calculation suggests that the aggregate effect of the CHF shock resulted in a 0.85 percentage point reduction in local currency corporate lending growth in Hungary between 2014:Q4 and 2015:Q4. See more details on this calculation in footnote 2.

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Appendix A Appendix tables and figures

A.1 CHF CORPORATE LOANS BY ISSUING YEAR

Table 14
CHF corporate loans in 2014 by issuing year

Year	number
2001	1
2002	6
2003	4
2004	99
2005	262
2006	584
2007	1665
2008	1570
2009	75
2010	51
2011	48
2012	51
2013	24
2014	22
N	4462

Notes: This table displays the issuance dates of Swiss franc (CHF) corporate loans to non-financial, non-exporting firms, as recorded on the balance sheets of 44 sampled banks in 2014. Notably, 95 percent of these loans were issued before 2009. The Credit Registry indicates that in 2014, there were 4,462 CHF corporate loans linked to 3,704 firms. On average, these loans had a maturity of 8.5 years, which is substantially longer than the average maturities for corporate loans in euros (4.5 years) and Hungarian forint (3.7 years). After 2008, only a few hundred firms received new CHF loans from banks.

A.2 SUMMARY STATISTICS FOR BANK VARIABLES

Table 15
Summary statistic: Bank variables

	Obs	Mean	Sd	Pc10	Pc90
ROA	44	-0.451	1.473	-2.199	0.595
Non performing loan ratio	44	0.112	0.067	0.041	0.186
Log Total Asset	44	11.333	1.957	9.290	14.490
Tier 1 capital ratio	44	0.170	0.064	0.116	0.262
Log RWA	44	10.528	2.121	8.404	13.983
Loan to deposit ratio	44	1.016	1.455	0.367	1.665
CAR	44	18.304	5.561	13.271	28.042
Loan to RWA	44	0.946	0.273	0.644	1.221
CHF loan to RWA ratio	44	0.125	0.130	0.022	0.299
CHF swap to RWA ratio	44	-0.035	0.083	-0.165	0.000
Interbank loan to RWA ratio	44	0.201	0.399	0.028	0.326
Foreign loan to RWA ratio	44	0.144	0.227	0.000	0.523

Notes: This table displays summary statistics for the bank-level variables used in our empirical analysis. It covers 44 sample banks, with all variables measured at the end of 2014.

A.3 ALL REGRESSOR COEFFICIENTS IN THE BASELINE BANK LENDING ANALYSIS

Table 16
Full regression

Variable	Coefficient	Std. Dev.
CHFLoan	-0.110***	0.034
Net CHF asset position	0.003	0.054
Net CHF swap position	0.022	0.050
Loan to asset share	0.040*	0.022
Capital adequacy ratio	0.069	0.044
Loan provision ratio	0.032	0.021
Loan to deposit ratio	-0.116***	0.021
Low tier one capital ratio dummy	0.036	0.031
Deposit to liability ratio	-0.084	0.058
ROA	0.034	0.023
Inter-bank loan ratio	0.011	0.018
Liquidity ratio	0.028	0.045
Observations	10,052	
R^2	0.394	
Firm fixed effect	Yes	
Firm borrowing type	M	

*Notes: This table provides detailed regression coefficients for all control variables used in Column (1) of Table 4. The dependent variable, gm(loan), represents the normalized growth rate of loans issued by bank b to firm j from the pre-crisis period (2014:Q1 to 2014:Q4) to the post-crisis period (2015:Q1 to 2015:Q4). The main independent variable is the unhedged CHF corporate loan to total asset ratio (CHFLoan), measured at the end of 2014. Standard errors are clustered at the bank level. Significance levels are denoted as *** for 1%, ** for 5%, and * for 10%.*

A.4 REGRESSION WITH ALTERNATIVE LOAN DEFAULT DEFINITION: 30 DAYS

Table 17
Link between CHF corporate loan ratio and non performing loan ratio change

	(1) ΔNPL_{Q1}^{CHF}	(2) ΔNPL_{Q2}^{CHF}	(3) ΔNPL_{Q3}^{CHF}	(4) ΔNPL_{Q4}^{CHF}
Panel A: WLS regression				
CHFLoan	0.660***	0.938***	0.977***	0.717***
	(0.059)	(0.067)	(0.056)	(0.066)
R-squared	0.876	0.913	0.940	0.860
Number of observations	44	44	44	44
Panel B: FE regression				
CHFLoan	0.606***	0.908***	0.942***	0.731***
	(0.052)	(0.048)	(0.039)	(0.020)
Firm fixed effect	Yes	Yes	Yes	Yes
R-squared	0.877	0.910	0.950	0.922
Number of observations	10,052	10,052	10,052	10,052
Bank controls	Yes	Yes	Yes	Yes
Interest rate Compensation	Yes	Yes	Yes	Yes
Firm borrowing type	M	M	M	M

*Notes: This table presents the results examining the direct relationship between the unhedged CHF corporate loan ratio and subsequent changes in the CHF non-performing loan (NPL) ratio. The dependent variable, the change in the CHF NPL ratio, spans from 2014:Q4 to each subsequent quarter in 2015, as shown in columns (1) to (4). The CHF NPL ratio, defined as the ratio of non-performing Swiss franc loans (loans late by more than 30 days) to total corporate loan assets, is calculated using the quarter-end exchange rate to convert all loans to the local currency. The ratio is scaled by 100, so the coefficients represent changes in percentage points. The primary independent variable is the unhedged CHF corporate loan ratio, measured at the end of 2014. All columns incorporate the same bank controls as those in the baseline regression. Panel A of the regression models uses bank asset-weighted least squares with bank-level data, while Panel B incorporates firm fixed effects in line with the loan-level bank lending analysis, using loan-level data. Standard errors are clustered at the bank level. Significance levels are denoted by *** for 1%, ** for 5%, and * for 10%.*

A.5 REGRESSION WITH NEW DEFAULT RATIO

Table 18
New default ratio: defualt between 30 to 90 days

	(1)	(2)	(3)	(4)
	WLS	FE	WLS	FE
	$\Delta NPL^{CHF}_{2015Q1}$	$\Delta NPL^{CHF}_{2015Q1}$	$\Delta NPL^{CHF}_{2015Q2}$	$\Delta NPL^{CHF}_{2015Q2}$
FMismatch	0.185***	0.163***	0.095***	0.099***
	(0.027)	(0.020)	(0.030)	(0.022)
Bank Controls	Yes	Yes	Yes	Yes
Interest Rate Compensation	Yes	Yes	Yes	Yes
R^2	0.803	0.816	0.550	0.699
Number of observations	44	10,052	44	10,052
Firm fixed effect	No	Yes	No	Yes

*Notes: This table explores the direct relationship between the unhedged CHF corporate loan ratio and subsequent changes in the newly defined CHF non-performing loan (NPL) ratio. The dependent variable is the change in the new CHF NPL ratio from 2014:Q4 to 2015:Q1 and from 2014:Q4 to 2015:Q2 , defined as the increase in newly delayed Swiss franc loans (with payment delays ranging from 30 to 90 days). The ratio is scaled by 100, meaning the coefficients represent changes in percentage points. The primary independent variable is the unhedged CHF corporate loan ratio, measured at the end of 2014. All columns incorporate the same bank controls as those in the baseline regression. Standard errors are clustered at the bank level. Significance levels are indicated by *** for 1%, ** for 5%, and * for 10%.*

Table 19
New default ratio: defualt between 30 to 180 days

	(1)	(2)	(3)	(4)
	WLS	FE	WLS	FE
	$\Delta NPL^{CHF}_{2015Q1}$	$\Delta NPL^{CHF}_{2015Q1}$	$\Delta NPL^{CHF}_{2015Q2}$	$\Delta NPL^{CHF}_{2015Q2}$
FMismatch	0.222***	0.228***	0.190***	0.185***
	(0.036)	(0.016)	(0.030)	(0.024)
Bank Controls	Yes	Yes	Yes	Yes
Interest Rate Compensation	Yes	Yes	Yes	Yes
R^2	0.786	0.595	0.823	0.717
Number of observations	44	10,052	44	10,052
Firm fixed effect	No	Yes	No	Yes

*Notes: This table explores the direct relationship between the unhedged CHF corporate loan ratio and subsequent changes in the newly defined CHF non-performing loan (NPL) ratio. The dependent variable is the change in the new CHF NPL ratio from 2014:Q4 to 2015:Q1 and from 2014:Q4 to 2015:Q2 , defined as the increase in newly delayed Swiss franc loans (with payment delays ranging from 30 to 180 days). The ratio is scaled by 100, meaning the coefficients represent changes in percentage points. The primary independent variable is the unhedged CHF corporate loan ratio, measured at the end of 2014. All columns incorporate the same bank controls as those in the baseline regression. Standard errors are clustered at the bank level. Significance levels are indicated by *** for 1%, ** for 5%, and * for 10%.*

A.6 CHF LOAN DEFAULT RATE

Table 20
Statistics for the CHF loan default rate

	CHF	EUR	HUF
average late payment days			
2014	521.4	88.2	80.8
2015	707.8	103.4	95.9
net increase rate	35.75%	17.23%	18.69%

This table offers a comparative overview of the average number of late payment days across various currencies. A loan is categorized as defaulted when a payment delay exceeds 90 days. Notably, the average number of late payment days for Swiss franc loans experienced a significant increase between the years 2014 and 2015.

Appendix B Variable definition

DEPENDENT VARIABLES

Variable	Definition
Change in HUF Loan Amount	Standardized growth rate between the pre- and post-shock loan averages, based on the contract amount.
Exit Dummy	Set to one if a bank-firm credit relationship established before the shock is terminated during the post-shock period.
Change in Non-Performing Loans Ratio	Change in the ratio of CHF corporate loans more than 90 days overdue to total corporate loans, compared between each quarter of 2015 (Q1, Q2, Q3, Q4) and the end of 2014 (Q4).
Change in CAR	Changes in the capital adequacy ratio between the end of 2014 (Q4) and subsequent quarters in 2015 (Q1, Q2).
Firm Capital	Logarithmic growth rate of the firm's total capital over two years.
Firm Liquidation	Set to one if the firm failed to submit a corporate tax report in 2015, indicating potential cessation of operations or liquidation.

FIRM LEVEL CONTROLS

Variable	Definition
Bank Loan Share	The proportion of the loan amount (contract value) between firm j and bank i relative to firm j's total aggregated loan amount.
Capital Adequacy Ratio	Ratio of a bank's capital to its risk-weighted assets.
Provision to RWA	Ratio of loan loss provisions to risk-weighted assets.
Loan-to-Deposit Ratio	Ratio of a bank's total loans to its total deposits.
Low Tier One Capital Dummy	Equals one if the tier 1 capital to risk-weighted assets ratio is less than 10%.
Deposits to Liability Ratio	Ratio of total deposits to total liabilities.
ROA	Return on assets, calculated as net income divided by total assets.
Interbank Loans to RWA Ratio	Ratio of interbank loans to risk-weighted assets.
Liquidity to RWA Ratio	Ratio of liquid assets to risk-weighted assets.
CHF Household Loan Ratio	Ratio of CHF-denominated household loans to the total balance sheet.
CHF Net On-Balance Sheet Mismatch	Ratio of the sum of CHF assets minus CHF liabilities to the total balance sheet.
CHF Net Off-Balance Sheet Mismatch	Ratio of net CHF derivatives positions (swaps and futures) to the total balance sheet.

BANK LEVEL CONTROLS

Variable	Definition
Firm Size	Categorized as micro, small, medium, or large based on the annual sales.
Foreign Ownership Dummy	Set to one if at least 50 percent of the firm's share capital is owned by foreign entities.
Age	The number of years since the firm was founded.
County	Dummy variables representing each of the 19 counties and the capital within Hungary.
Leverage	Calculated as one minus the ratio of equity capital to total balance sheet value.
Collateral	Ratio of fixed assets to the total balance sheet value.
Negative Equity Dummy	Set to one if the firm's equity capital is negative, indicating financial distress.
Industry	Classification of the firm's primary business activity into one of 19 industry sectors based on the NACE classification system.

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