BANAI, Ádám

Bank Behavior before and in the Crisis

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1. FX LENDING IN HUNGARY

Foreign currency lending and its consequences were a definitive factor in how the global financial crisis unfolded in Hungary. Following 2008, it became obvious that the earlier practice of taking on debt denominated in foreign currencies placed a significant burden on all economic actors (corporations, households, the banking system and the state as well). Seven years after the onset of the crisis in Hungary, banking system processes are still defined by the legacy of earlier foreign currency lending. A thorough analysis of local events and a summation of the lessons learned are vital in order to avoid the reemergence of similar risks and to provide an example to other nations as well, seeing that foreign currency lending is still prevalent around the world. In what follows, we first present the process of the proliferation of foreign currency lending. Second, the studies constituting further chapters examine risks emerging from foreign currency lending from the perspective of the banking system.

1.1 The Literature of Foreign Currency Lending

1.1.1 The concept and types of dollarization

"Foreign currency lending" is not a unique Hungarian phenomenon: the so-called "financial dollarization" is well known in the developing world as well. When defining dollarization, it is important to differentiate between "complete" (de jure) and "partial" (de facto) dollarization. In the former case, the monetary authority makes the decision for the country in question to officially revert to the use of a foreign currency (most often USD or EUR) as legal tender, and thus that foreign currency fulfills the role of money from that point on.

In the latter case, economic actors individually make the decision to use a foreign currency in the course of specific transactions or to hold a part of their assets or liabilities in foreign currencies. This latter form of dollarization is most relevant from the Hungarian perspective, thus this is what we elaborate in the following and what we refer to under the phrase dollarization.

Dollarization can happen on both the deposit and loan sides. De Nicoló et al. (2003), for example, focus particularly on the former. In the countries they examine in their study, over 90% of domestic deposits were held in foreign currencies (e.g. Cambodia or Bolivia). The

ex-Yugoslavian states represent the primary European examples for similarly high rates of dollarization on the deposit side. This phenomenon is generally the result of a reaction to significantly weakening exchange rates. From a Hungarian perspective, loan side dollarization is more relevant, as savings denominated in foreign currencies have not played a major role in Hungary to date.

An important factor when examining dollarization is whether it impacts the private sector, the public sector, or both. Berkmen and Cavallo (2009), for instance, specifically analyze dollarization affecting different sectors. Although the share of government debt denominated in foreign currencies is also significant, this study focuses on foreign currency debts of the private sector (predominantly households).

1.1.2 Causes of dollarization

Research into the reasons behind dollarization abounds in the literature. Calvo's 1999 study is often considered the initial classic, examining primarily dollarization typical of Latin American and East Asian emerging markets. He considers three distinct issues. The first is the threat of asymmetric shocks. As a result of dollarization, the emerging nation forms, in a certain sense, a currency union with the United States (or Eurozone, Switzerland etc.), which limits the scope of its independent monetary policy significantly. External shocks impact the economies of both countries, but this impact is not necessarily identical, and may thus call for different monetary policy interventions - the prospect of devaluation often arises in developing nations. According to Calvo, the experiences of the 1990s show that currency devaluation would not entirely solve the crisis in emerging nations, and that structural policy interventions modifying the structure of their economies would also be necessary, implying that independent monetary policy and the opportunity to devalue do not themselves necessarily hold the key to countering the crisis. The second potential issue is that the Central Bank is hardly capable of fulfilling its role as lender of last resort in a foreign currency. According to Calvo, other tools of monetary policy can be considered in such cases, for example the establishment of stabilization funds to contribute to the liquidity of commercial banks. The third issue is debt inflation, which Calvo considers the most realistic threat. According to Calvo, however, exchange rate devaluation is not the

only action that can be taken to mitigate this threat. As an example, he cites the advantages of developing the market for hedges against inflation (Calvo, 1999).

Calvo also considers the causes leading to liability dollarization. In his study, he emphasizes two main causes of borrowing in foreign currencies: the first is that emerging economies need foreign funds for development, which foreign financial institutions provide in their own currencies, as that is what is primarily at their disposal.[1] The second reason is that exchange rate policy is much more volatile in emerging nations, and consequently, these lending institutions would assume excessive risk lending in the emerging nation's own currency.

Calvo's conclusions generated serious debate. Eichengreen et al. (2003), for example, used the phrase "original sin" discussing foreign currency lending. Others (e.g. Ize-Levy Yeyati 2003, Ize and Parade 2002) showed that in countries with considerable dollarization, following devaluation brought on by crises, the risk of bank crises is greater, economic growth is more volatile and financial intermediation is less deep (see also Nicoló-Honohan - Ize 2005, Levi-Yeyati 2005).

The portfolio model created by Ize and Yeyati (2003) is one of the most often used analytical frameworks to examine the emergence of dollarization. This approach is based on the usual assumption that risk-neutral investors choose the composition of their portfolios optimizing on the expected return/variance space. Under this assumption, even when uncovered interest rate parity holds and expected returns the same, variance is different across assets denominated in foreign and local currencies. In other words, as inflation volatility grows compared to real exchange rate volatility, holding domestic assets gradually becomes riskier and holding foreign currency assets more profitable.

Ize (2005) presented a model framework in which it is possible to analyze deposit and loan side "dollarization" contemporaneously, supplementing the work done by Ize and Levy-Yeyati (2003). Depositors base their decisions on how they are able to minimize their

[1] This is what Eichengreen et al. (2003) call „original sin"

portfolio variance. Borrowers, in turn, make their decision to maximize their objective function in presence of the risk of default. One important element of the model is that the currency structure of deposits and loans is identical in aggregate, thus, in this case, the bank acts only as an intermediary. The important message this holds for us is that borrowing or holding assets in foreign currencies can also be rational under uncovered interest rate parity.

Castro and Moron (2005) examined the dollarization phenomenon in data from Peru. They observed that inflation targeting may be an appropriate tool to reduce dollarization, as considerable inflation volatility increases the probability of the emergence of excessive financial dollarization. Fear of floating exchange rates causes monetary policy to attempt to keep exchange rates stable. This latter, in turn, could make economic actors gradually turn towards the use of foreign currencies.

In the 2000s, besides the "dollarization" of South American and East Asian economies, a growing number of studies began to focus on the phenomenon of so-called Eastern European "financial euroization" as well (e.g. Backe-Zumer 2005, Basso et al 2007, Luca-Petrova 2008, Rosenberg-Tirpák 2008, Neanidis-Savva 2009, Zettelmeyer et al 2010, EBCI 2010, Banai et al 2010, Bethlendi 2011). While earlier research mainly analyzed deposit "dollarization", later papers - among them, almost all studies focusing on Eastern Europe - consider both deposit and loan side euroization.

From a Hungarian perspective, Basso et al. (2007) is one of the most important studies. Within the model they construct, they examine the financing and saving decisions of households and corporations in terms of currency denomination, incorporating banks who decide the composition of their balance sheet as profit-maximizing actors. Contradicting the premise stated by Ize (2005), they show that deposit and loan side "euroization" do not necessarily emerge together (later Hungarian data confirms this). In contrast to the Ize model, in this case, banks do not only play the role of financial intermediary, in the sense that they themselves decide what volume of foreign currency liabilities to hold. Consequently, foreign currency deposits and liabilities need not necessarily be in equilibrium. They highlight a number of factors which may contribute to "euroization". One possible cause is easy access to foreign capital. This, while increasing the chance of

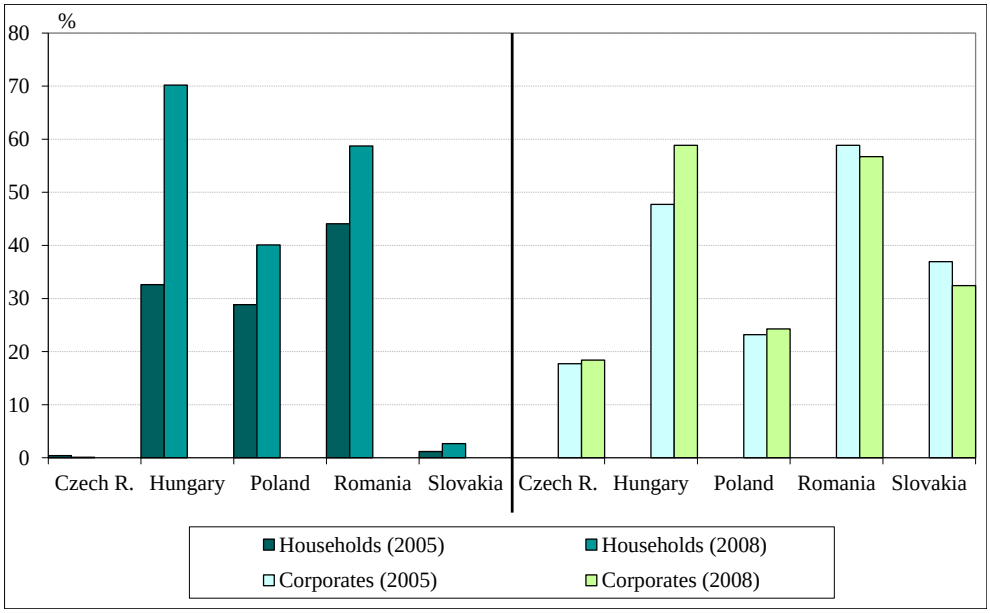
foreign currency lending, also decreases deposit dollarization. Foreign funding often happens through the foreign owner institution, thus, considerable foreign ownership within the banking sector clearly has the potential to strengthen this effect. The strong presence of such foreign financial institutions is typical in the Central and Eastern European region examined in the paper. The second factor they consider significant is the interest rate differential. The large difference between domestic and foreign interest rates appears in the interest rates of loans denominated in various currencies as well, and could thus render choosing the foreign currency more profitable. Their third argument is the so-called "portfolio approach": in line with Ize (2005), if the variance of inflation is greater than the volatility of the real exchange rate of the foreign currency, it is rational to choose the foreign currency even under uncovered interest rate parity. Finally, the fourth factor they consider relevant is the openness of the country in question. This, however, they find definitive primarily in the case of corporate dollarization. With respect to the latter, the authors also remark that the model shows more significance for corporates than households. They found that dollarization is, in general, less typical in case of households than it is in case of corporations, which could be explained by the fact that they have considerably fewer options to mitigate exchange rate risk (Basso et al. 2007).

1.2 Foreign Currency Lending in Hungary

It is clear from Chart 1 that there are significant differences between the region's countries in terms of both the prevalence of foreign currency loans and the dynamics of foreign currency lending. In the following, we examine the evolution of various banking system and macro variables in these countries and use these to attempt to explain the observed differences. We have included data from 5 countries in our analysis: the Czech Republic, Poland, Hungary, Romania and Slovakia. It was a primary consideration to include only EU member states in the analysis, as their banking systems all developed in a similar manner. Of the region's EU states, we excluded Slovenia, as the ownership structure of Slovenia's banking system is quite unique which could prove misleading. The three Baltic states and Bulgaria were also excluded, as these countries had currency boards (or comparable systems), and thus the causes and consequences of dollarization were completely different. In the course of the study, we mainly focus our analyses on the time

period between 2000 and the Lehman collapse, however, in certain cases, we use shorter time series due to lack of data.

Chart 1: Proportion of foreign currency loans in the region's states before the crisis



Source: Banai et al. (2010b)

Note: year end data on actual exchange rate. Sum of FX loans to total loans.

1.2.1 The State of the Banking System

From the causes listed by Basso et al (2007), one of the most relevant factors on the supply side is whether banks have access to funds denominated in foreign currencies (a question which already appeared in Calvo (1999) as well). This is more likely if the presence of foreign banks in the given banking system is significant.

'In the 1990s, several bank crises swept across the countries of the Central and Eastern European region, compromising the capital positions of the majority of banks. Thus, state intervention became unavoidable. These crises were mainly caused by the extremely bad quality loan portfolios inherited from previous systems. Meanwhile, bad legacies notwithstanding, banks continued expansive lending as before. They lent almost exclusively to corporate sector devastated by the recession, often in line with political interests. As a consequence of the collapse of these corporations, some banks' loan portfolio lost all value and the rate of non-performing loans rose to 25-30%, leading to the considerable losses. Banks were thus forced to limit their lending activities, which, in turn,

exacerbated the entire process further. It became obvious that the banking system alone would not be able to ride out the crisis on its own, and, albeit at different times, each of the five states was forced to launch bank consolidation programs. Credit institutions were recapitalized and made efforts to improve the quality of their portfolios. This did not, however, prove to be enough. It became clear that, in lieu of domestic savings, it would be necessary to turn to foreign strategic investors to stabilize these banking systems.' (Banai et al 2010b).

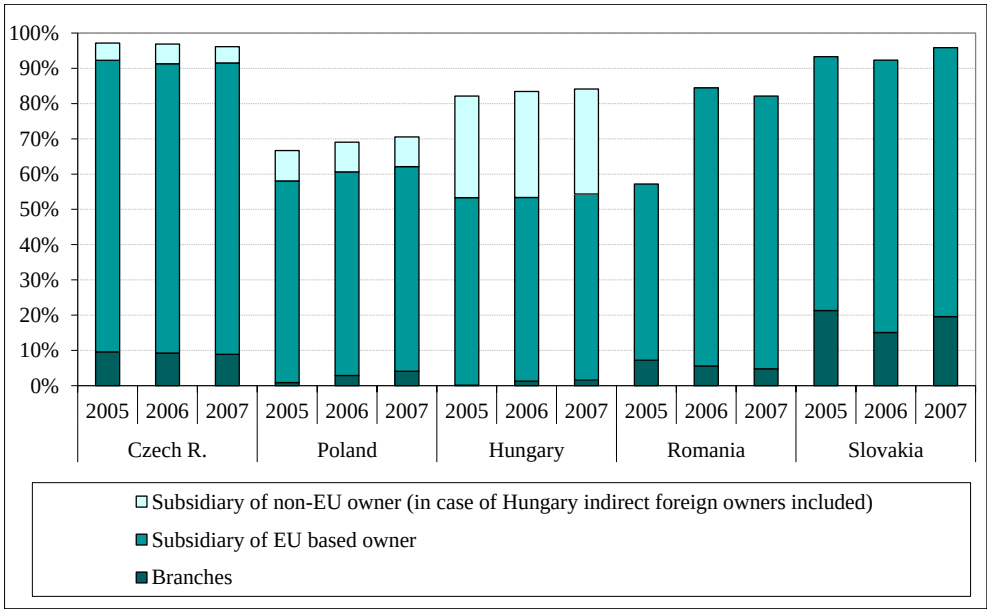
The first country in the region to see the transformation of the banking system begin was Hungary in 1994. The decisive factors during privatization were price and a willingness to undertake further capitalization, as the primary goal was the reinforcement of undercapitalized, recently consolidated banks. Additionally, applicants' ability to develop the given bank's operations - the quality of banking - was also taken into consideration. Ultimately, most of the previously state-owned banks were successfully privatized by 1997. As a final step, in 2003, Postabank, completely recapitalized in 1998, and FHB, founded in 1997, were also privatized.

The region's other states saw similar processes play out during the transformation of the banking systems, albeit somewhat later. In Poland, the state had to recapitalize a number of significant banks between 1993-1996, and the larger part of the privatization process took place in the new millennium. In the Czech Republic, where so-called voucher privatization impeded the emergence of prudent owners, several financial institutions of varying sizes went bankrupt between 1994-1996, and the four largest banks were eventually nationalized between 1997-1998. At the start of the new millennium (2000/2001), two major banks again required state assistance, before eventually ending up in the hands of foreign investors. In Slovakia, following multiple rounds of voucher privatization, several large banks ended up requiring state assistance between 1997-2000. However, thanks to the reform of the banking system, by 2002, the proportion of foreign ownership exceeded 90%. Transformation of the banking system in Romania started relatively late compared to its regional counterparts. Economic difficulties following the regime change didn't allow for the privatization of the banking system before the end of the 1990s. The first major privatization transaction was concluded in 1999 (Barisitz, 2008). 2005 can be considered a

milestone of the Romanian transformation process, as this was the year Erste Bank became the owner of Banka Commercial Romana, the largest Romanian Bank. With this, the proportion of foreign ownership in the sector surpassed 80%.

By the eve of the financial crisis, foreign ownership had reached or exceeded 70% in each of the countries in question, the differences in their individual journeys notwithstanding (Chart 2). As Bonin (2010) suggest, the speed and depth of foreign banks entry in a region is very unique. Examination of this phenomena may result important lessons.

Chart 2: Market share of foreign banks in the CEE-5



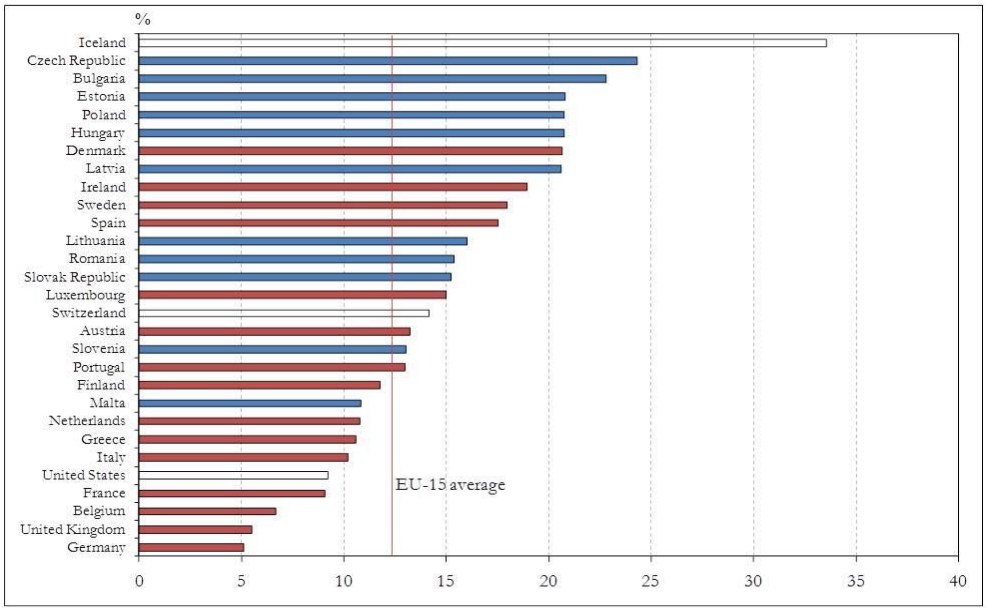
Source: Banai et al. (2010b)

Presence of significant foreign ownership increases the chances of access to foreign capital. The profitability prospects of the given subsidiaries, however, are particularly important in terms of the intra-group allocation of funding and capital. It is worth allocating more funding and capital to a subsidiary with higher expected profits, and thus, at the same time, supporting its further growth.[2] From this perspective, the entire regional banking system was performing very well prior to the crisis. The average profitability of the banking systems of the countries included in our study between 2004-2008 exceeded the European

[2] We consider macro factors (presence of adequate savings, demand for foreign currency loans, etc) at 1.2.2 subchapter.

average, and, consequently, also the level of profitability available in the parent companies' home countries (*Chart 3*). This meant that foreign banks had an incentive to allocate their resources into the region.

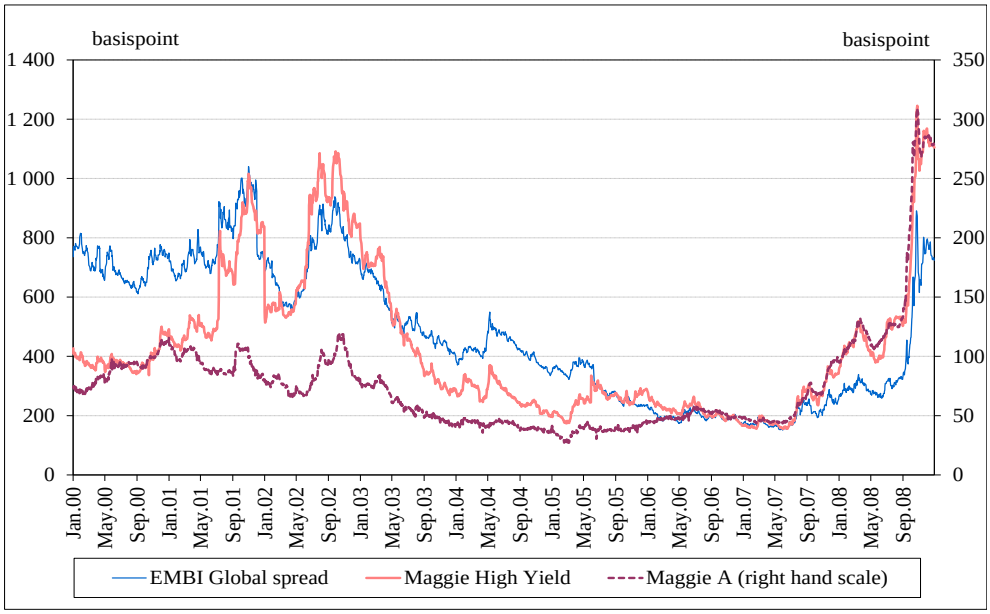
Chart 3: Performance of the banking systems of individual states before the crisis (2004-2008)



Source: ECB, MNB

Finally, it is also worth taking a glance at the situation on global markets. By 2003, turbulence following the burst of the dotcom bubble had quieted down, and markets throughout the world were characterized by tranquility until the end of 2007. As a result of the high risk-taking willingness, returns decreased to very low levels not only in developed markets but also in emerging economies. Seemingly infinite liquidity was in constant search of ways to achieve higher returns, consequently, emerging markets previously considered riskier were able to get funds at comparatively low cost (*Chart 4*). This contributed doubly to the region's banks' access to foreign currency financing, as the region was able to finance itself cheaply both directly and through the parent institutions.

Chart 4. Risk indices in time



Source: JP Morgan, Datastream
Note: EMBI Global measures returns available from emerging market loan instruments. Maggie indices measure the performance of debt instruments denominated in euros. They aggregate market performance of government bonds, corporate bonds and mortgage bonds.

Thus, altogether, the structure of the banking system contributed to the emergence of foreign currency lending, insomuch as foreign owners provided easy access to foreign currency capital (in line with the 2007 study by Basso and Calvo). These relatively easy financing opportunities were further reinforced by the fact that banks seemingly assumed only minimal risk by issuing mortgage bonds. Moreover, the know-how of household lending could be easily implemented in regional subsidiaries of foreign parents (or at least it was relatively easy compared to the more sophisticated expertise needed for lending to enterprises, as suggested by Bonin et al. (2014)). Although these factors do, to a certain extent, explain the proliferation of foreign currency lending, they do not shed light on the causes of the differences observable across the countries in the sample. To explore these, we turn to the examination of the individual states' macroeconomic development.

1.2.2 Macro Variables

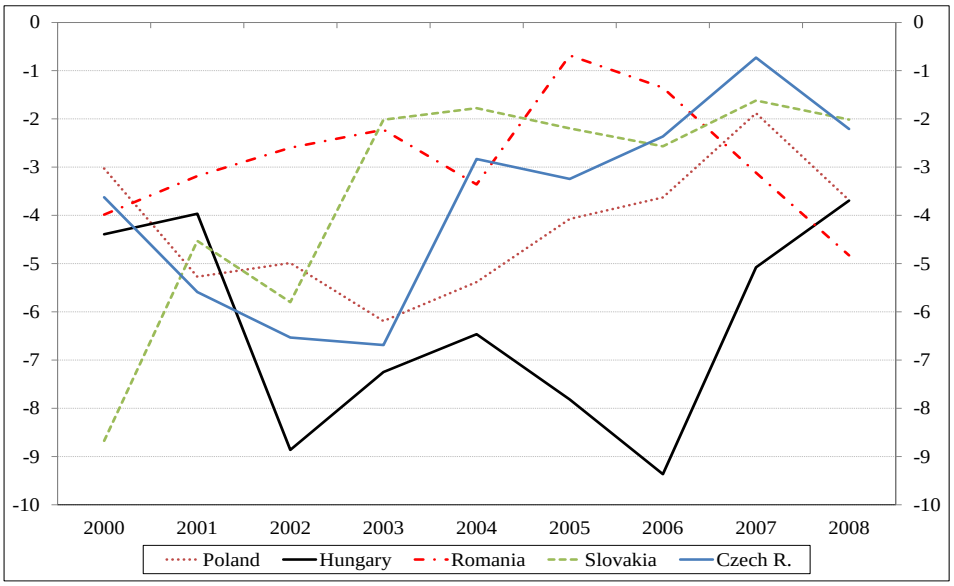
In our examination of macroeconomic processes, we will concentrate on the ones most important in terms of the proliferation of foreign currency lending. The risks emerging in

an economy can be traced back to countless factors and their interrelations, thus it is impossible to cover each and every one.

Fiscal policy

Hungarian government debt was quite high following the regime change, and was predominantly financed from abroad. From the mid-90s, decreasing the debt-to-GDP ratio and, consequently, improving risk perception became a high priority goal. Between 1995 and 2001, government debt was successfully reduced from around 80 percent to around 50 percent, which was about equal to the level observable in Poland at the time. The period between 2002-2003 was, however, a turning point for fiscal trends in Hungary as well as the region's other countries: while Hungary was usually characterized by deficit over 7% percent of GDP, the sample's other countries displayed increasing fiscal discipline (*Chart 5*). Although the Hungarian government implemented major interventions to ensure budget sustainability, deficit still exceeded the regional average.

Chart 5: Evolution of the government budget balance in the sample's countries



Source: Eurostat

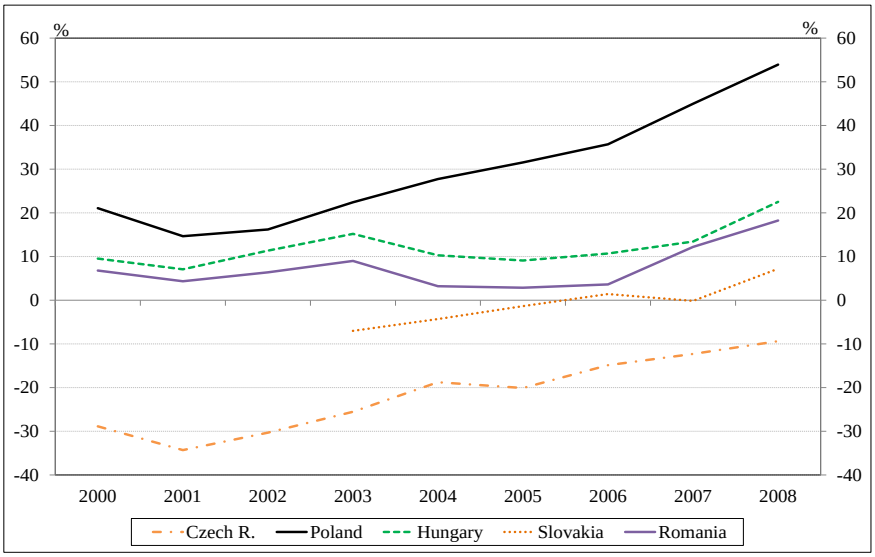
„As a result of consistently high government deficit, government debt as a percentage of GDP climbed from 52 percent in 2001 to 73 percent by 2009. This extensive increase in government debt can be explained by the consistent deficit of the primary balance. Prior to 2008, it last showed a sufficit in 2001. The introduction of a 13th-month pension, the 50% wage raise for public servants and the generous mortgage loan support scheme all played a

significant part in these negative fiscal developments *(Chart 6)*. The outlying primary deficit values of 2002, 2005 and 2006 also reflect major debt takeovers (e.g. MÁV, BKV, NA Rt., ÁAK Rt.) and - particularly in connection with the financing of highway construction in 2005 - the effects of ex-post charges. The fact that government expenditures were unable to stimulate the economy to the extent envisioned, that its growth was in fact the slowest in international comparison, should not be ignored either." (Király and Banai, 2012)

External balance and its consequences

As a consequence of its relatively high level of government debt (when compared to the region and the country's level of development), much of which was financed from abroad, Hungary had the largest net foreign debt of all countries examined. The indicator already exceeded the level displayed by the second-worst performing state, Poland, by 6-8 percentage points in the early 2000s, and by 2004, this difference had increased to 20 percentage points. Meanwhile, the indicator varied in the 0-10 percent range in each of the sample's other countries, even taking a negative value in the Czech Republic (Chart 6).[3]

Chart 6: Evolution of net external debt in the countries included in the sample

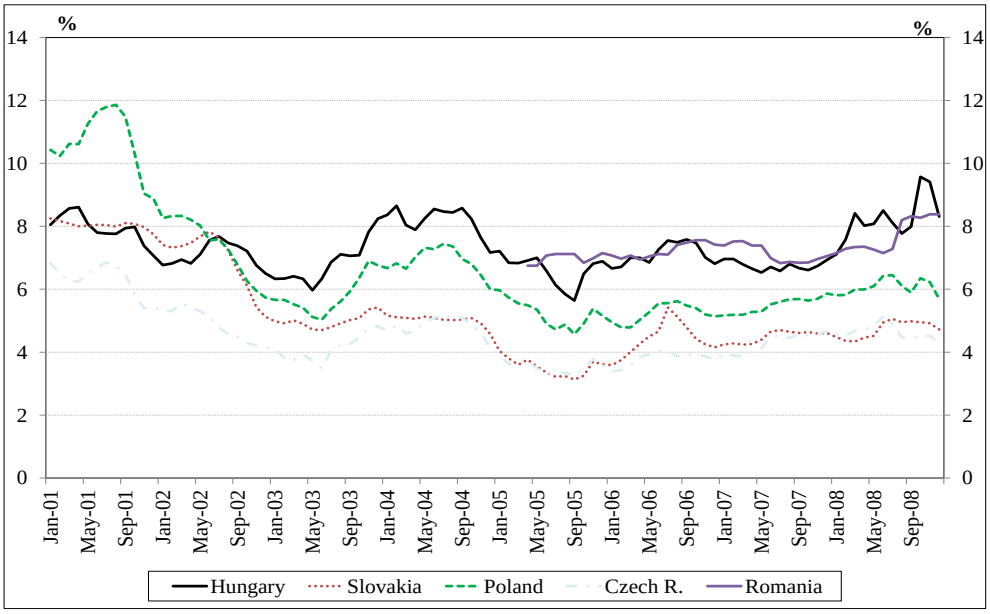


Source: Eurostat, Banai et al. (2010b)

[3] Borio (2014) demonstrates that net figures showing a balance need not imply safe financing.

High government debt and the similarly significant level of net foreign debt represented considerable risk to investors. Meanwhile, as we will see in the following, Hungarian economic growth was also the weakest in the region. As a consequence, the Hungarian state was forced to pay a considerable risk premium in comparison to the region's other countries (with the exception of Romania). The return on the 10-year government reference bond was 1-2 percentage points higher than in Poland preceding the crisis. The difference in comparison to the Czech Republic was even more conspicuous, reaching 3-4 percentage points (*Chart 7*).

Chart 7: Returns on 10-year government reference bonds in the sample's countries



Source: Eurostat

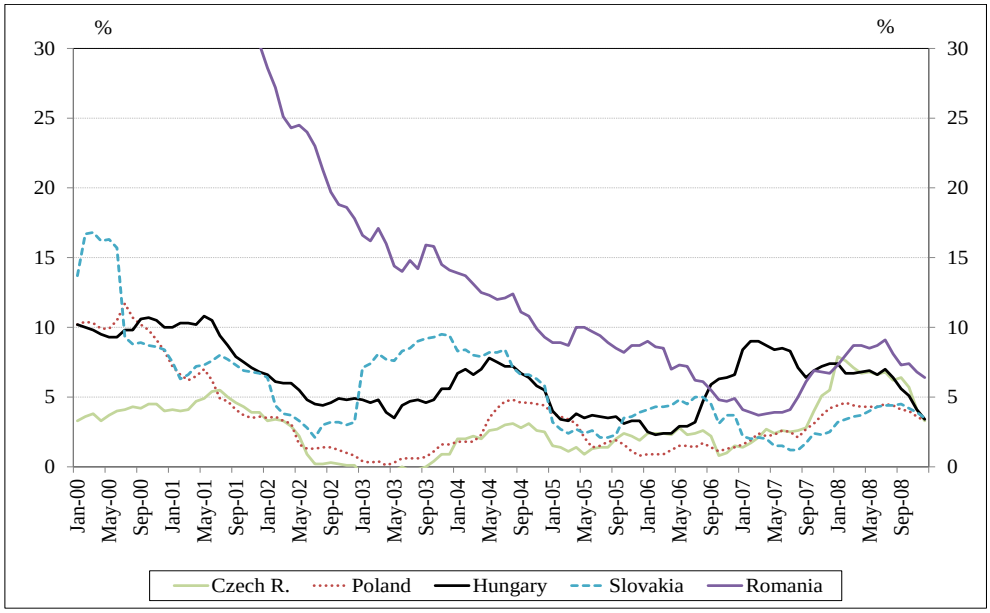
Note: For years preceding 2001, data was only available for the Czech Republic, hence we present data beginning with 2001.

Expansive fiscal policy does not only affect the level of debt itself, but can also negatively impact inflation processes as well. A 50% wage raise and the introduction of a 13th-month pension were among the primary causes of rising inflation in Hungary. Chart 8 shows that inflation in Hungary was not disproportionately high in comparison to the region's other states, it was still, however, among the highest. The average 5.5 percent rate experienced in the period between 2003-2008 was considerably higher than the Polish and Czech rates, which were both under 3 percent, and also somewhat higher than the Slovakian rate of 4.8 percent. It remained less, however, than the near 10 percent average rate of Romanian

inflation (*Chart 8*). On the other hand, the constantly high rate of Romanian inflation was not due to fiscal expansion.

The variance of inflation in this period (between 2000 and 2008) did not, however, exceed the regional average.[4] This is important because Basso et al. mention, among others, high inflation variance as one of the potential causes behind foreign currency lending. This observation thus implies that the inflation level itself counts as well as the variance.

Chart 8: Inflation time series for the sample's countries



Source: Eurostat

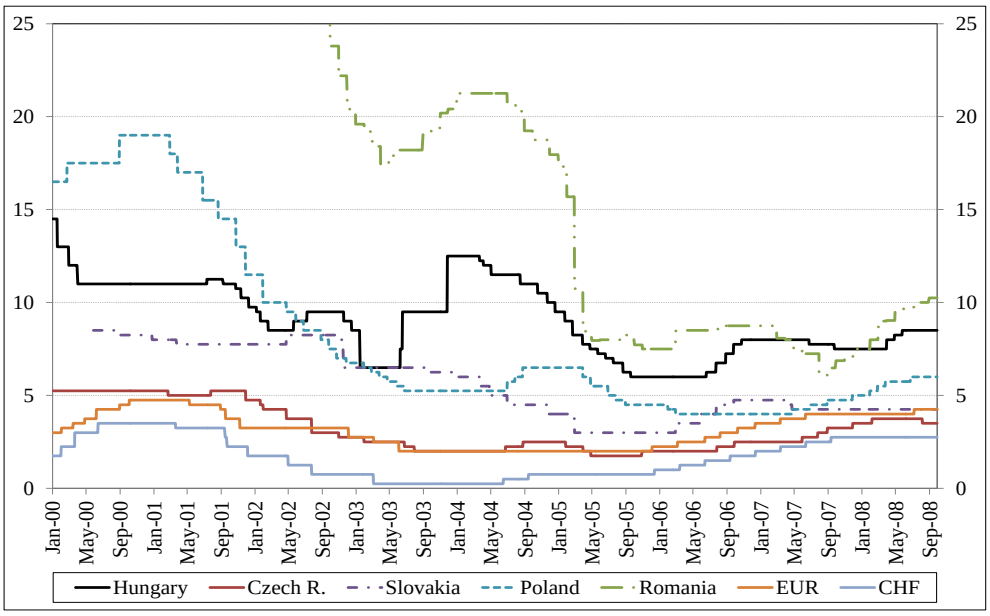
Note: We use the annual change in HICP as the indicator for inflation.

The nominal Hungarian interest rate, stemming from the above factors (risks due to high levels of indebtedness and relatively high inflation), was high even in regional comparison during the period preceding the crisis, as keeping the central bank rate high was necessary in order to achieve the inflation goal. Thus, between 2002-2008, the Hungarian central bank rate always exceeded the ECB rate by at least 3.5 percent, sometimes by as much as 10 percent, the average difference in the period being 5.6 percent. Meanwhile, in the Czech Republic, the interest rate differential with the euro gradually disappeared. From the end of

[4] Calculated using Rother's (2004) method, variance was 0.52 in the Czech Republic, 0.51 in Hungary, 0.35 in Poland, 0.52 in Romania and 0.75 in Slovakia.

2002, the difference between central bank rates no longer exceeded 0.5 percentage points, with the Czech rate occasionally the lower of the two. While in Slovakia, the interest rate differential with euro rates was still 4.5-5 percent at the beginning of this period, this soon began to decrease with the decrease of inflation. From early 2004, the difference was narrowing consistently, and shrunk to 1 percentage point by 2005. In Poland, at the beginning of 2002, the difference from the euro rate was larger even than in Hungary, however, as a result of the interest rate reduction cycle afforded by low inflation, the initial difference of about 6.5 percent reduced to 3.5-4 percent by 2003 and 2.5-3 percent by 2005, narrowing to around 1 percent by 2006. Only in Romania, where inflation decreased later and at a much slower rate, was the interest rate similar to its Hungarian counterpart, even exceeding it considerably at the beginning of the time series (*Chart 9*).

Chart 9: Time series of central bank rates in the sample's countries, the Eurozone and Switzerland

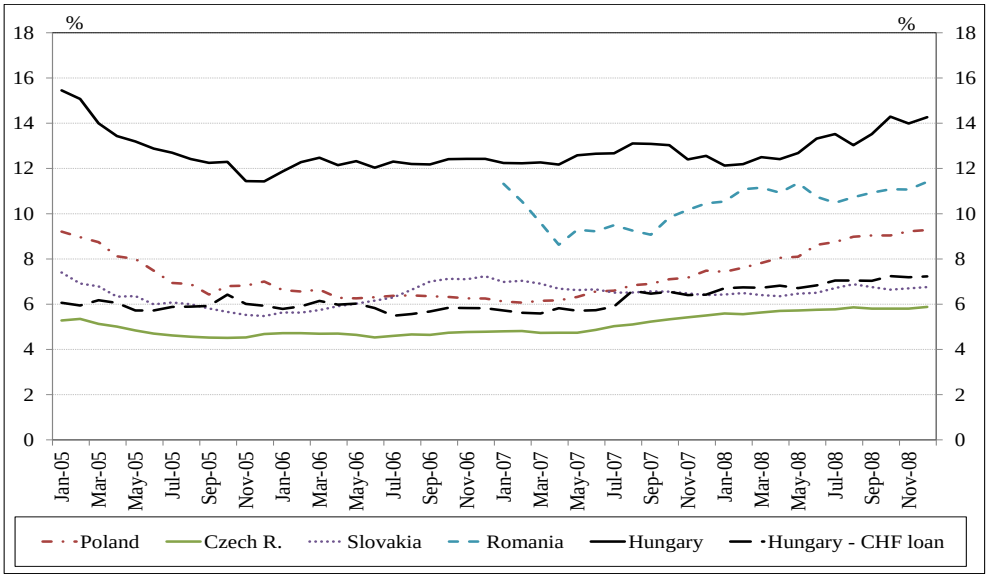


Sources: websites of central banks
Note: The Romanian central bank rate exceeded 25 percent at the beginning of the time series, however, we excluded these points for the sake of a better visualization of differences.

The significant central bank rate differential was also reflected by interest rates of household and corporate products. On mortgage loans, Hungarian households had to pay interest rates 6-10 percentage points higher than those their counterparts faced in the other three V4 states. Data for Romania is only available from 2007, but it is visible that by the two years directly preceding the crisis, loans denominated in the domestic currency had

also become cheaper there than they were in Hungary. In the 4 years before the crisis, the interest rates of Hungarian CHF mortgage loans were comparable to the interest rates on mortgage loans denominated in the domestic currencies of the other V4 states. Corporate lending also displayed tendencies similar to those observed in case of mortgage loans (*Charts 10 and 11*). It is important to note, however, that a significant number of corporations borrowing in foreign currencies also had foreign currency income and thus had a natural hedge against fluctuations of the exchange rate.

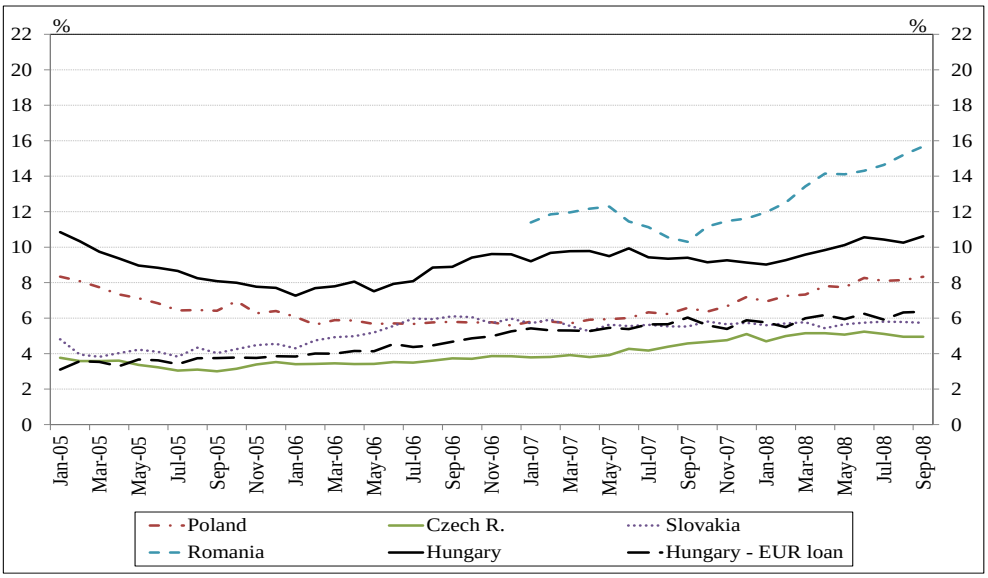
Chart 10: APR for new mortgage loans denominated in domestic currencies in the sample's countries and Hungarian CHF mortgage loans



Source: websites of central banks

Note: Data for the years prior to 2005 was unavailable in the majority of cases.

Chart 11: Interest rates for new corporate loans in the sample's countries and Hungarian EUR loans



Source: websites of central banks

Note: Data for the years prior to 2005 was unavailable in the majority of cases.

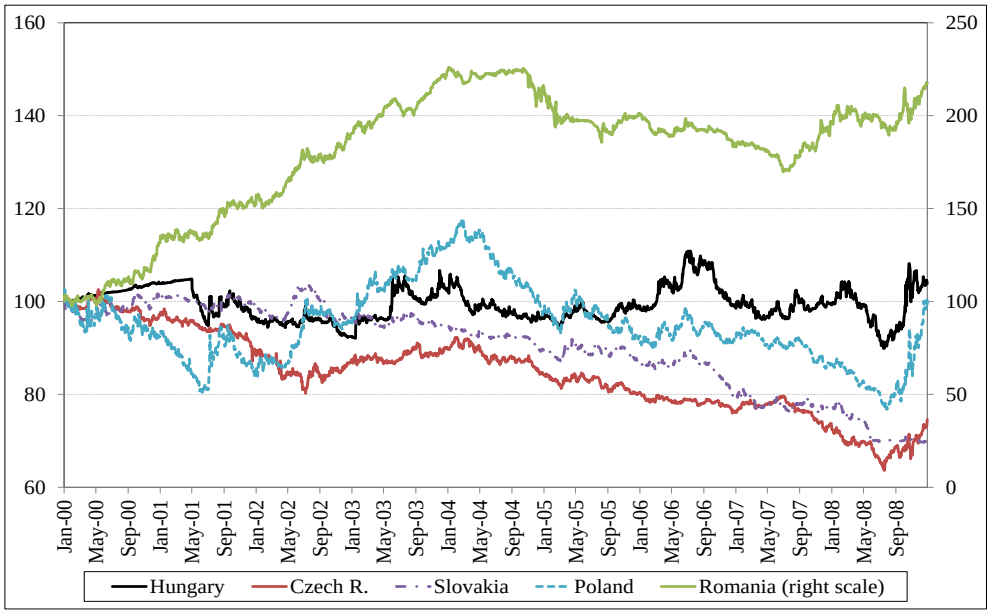
Additional factors

In terms of choosing the denomination of a loan to be taken out, the borrower's expectations regarding the fluctuation of the exchange rate are particularly important. Due to the long-maintained currency band and the "fear of floating" phenomenon, the forint exchange rate displayed high stability with respect to the euro, even strengthening somewhat in the period from 2003 leading up to the crisis. The forint also displayed similar stability with respect to the CHF, as the EUR/CHF exchange rate did not fluctuate significantly during the period in question. The one-month volatility of the euro exchange rate remained between 5-15 percent. This is not very high, taking into account the fact that, due to the interest rate differential, the monthly installment on a 20-year loan might have been up to 40 percent lower than was the case for forint denominated loans (Király and Banai, 2013).

Among the sample's other countries, the Czech Republic and Slovakia saw exchange rates strengthening steadily from the earlier 2000s onwards. This factor could itself have driven demand for foreign currency loans, as with near-identical interest rates, these strengthening exchange rates would have resulted in an altogether more favorable position for borrowers.

In Romania, the waves of weakening the leu went through in the period in question may have counteracted the emergence of foreign currency lending (Borio et al. 2007). In Poland, the zloty displayed stability with respect to the euro similar to that of the forint. The two-year period between 2002-2004 represented a significant difference, however, when the PLN/EUR exchange rate weakened from its around 3.5 level to 5 (Chart 12). This was the period when the Polish central bank cut the central bank rate from 10 percent to 5.25 percent during the course of 2 years. The primary reason for this reduction of interest rates was that the inflation goal required a lower rate. As a kind of "positive" side effect, however, Poland gained valuable experience on how dangerous foreign currency debts could be in case of a considerable weakening of the exchange rate.

Chart 12: Exchange rates of domestic currencies with respect to the euro in the sample's countries (2000.01.03.=100)

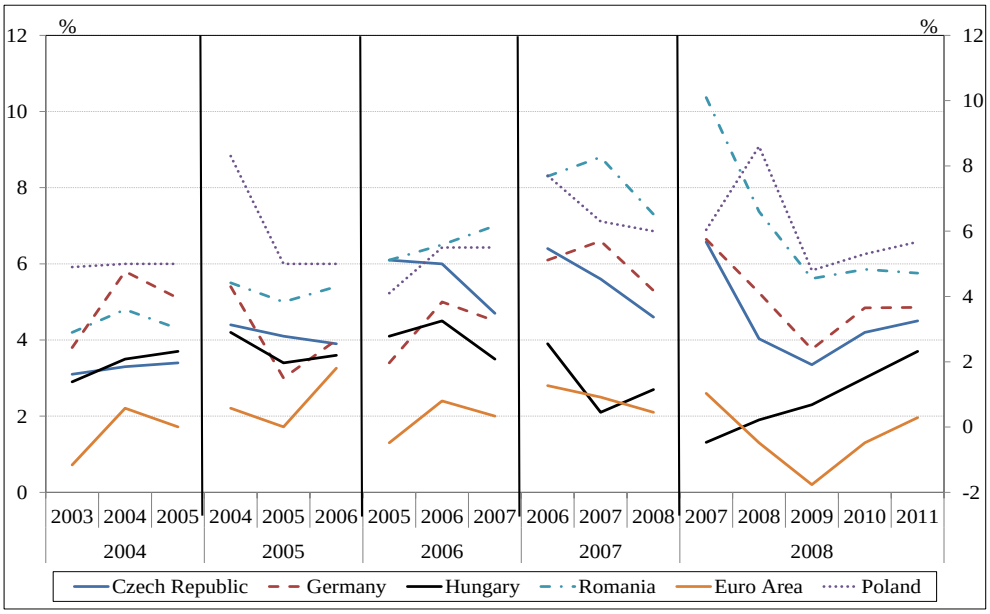


Source: Datastream

Finally, it is worth examining economic performance in brief. In the period from the 2000s to the crisis, the Czech Republic unequivocally performed best among the countries examined. It displayed the highest per capita GDP on average, followed by Hungary, Slovakia, Poland and, lagging far behind, Romania. This is particularly relevant in case of Romania, as although the economy's growth rate was relatively high, the low level itself does explain, to a certain extent, the relatively high risk premium observable in the country during the period in question.

Besides actual rates and levels, growth expectations are also important, as these also factor into income expectations. Although from 2004, the expected growth dynamics was lowest in Hungary, constant convergence to Western countries seemed guaranteed, which gave the population the false impression that repaying loans could not pose a serious issue (*Chart 13*).

Chart 13: Growth expectations in the individual states prior to the crisis



Source: IMF WEO

Note: forecasts compiled in summer of the given year and historical data from the previous year

1.2.3 Regulatory environment

Beside macroeconomic differences, the variation of the regulatory environment could also have contributed to the differences in the currency structure of credit observable across the countries examined. Banai et al. (2011) present a useful summary of potential regulatory interventions:

1) **Monetary instruments**: In Hungary, the central bank and the financial supervisory authority are two separate institutions, thus the former's main instrument to force a reduction of foreign currency lending is the regulation of reserve requirements. By stipulating a higher reserve requirement for foreign currency liabilities and/or paying lower interest rates, the central bank can make foreign currency lending more expensive. The disadvantage of this form of regulation is that it is relatively

easy to circumvent if banks raise foreign currency liquidity synthetically (e.g. combining spot and FX swap transactions or using FX forward). This would render it necessary to stipulate a reserve requirement for derivatives as well, which would, in turn, also make certain transactions unrelated to foreign currency lending more expensive, and which could have a number of significant market effects. Banks could still avoid negative effects by selling certain portfolio elements to other members of the bank group (international practice has shown examples of such actions). Finally, one other counter-argument was that modifying reserve requirement regulation would have meant a step back for the harmonization of European policy instruments.

2) **Administrative instruments:** Good examples of this set of instruments are the complete prohibition of loans unhedged against exchange rate risk or the specification of limits for such loans. The introduction of these measures limits or entirely discourages foreign currency lending, but only temporarily. This kind of aggressive intervention stimulates evasion and intensifies cross-border financial intermediation. The decrease in new loans has the potential to drastically reduce banks' profitability, which is a significant risk in terms of stability. These instruments also have a negative impact on interbank competition and banks' efficiency. Application of such measures is not in line with European practice and in many cases, is in fact explicitly forbidden for EU member states.

3) **Macro-prudential instruments:**

   - *Raising capital requirements:* many countries have tried to raise the cost of foreign currency lending this way, in order to force a reduction in its prevalence. Due, however, to Hungary's EU membership, this was not an option.

   - *Setting stricter limits for banks' open positions:* on the one hand, this can raise the cost of foreign currency lending to some extent, and can, on the other hand, also limit maturity risk stemming from synthetic positions. This can also mitigate the risk of banks being overly dependent on specific

financial markets. The question was, however, whether taking this step would have the potential to result in perceptible changes.

- *Imposing stricter non-price minimum loan conditions (LTV, PTI):* we have already seen that the level of these indicators (both LTV and PTI) was increasing steadily in Hungary before the crisis. Such a step, with limits chosen appropriately, would have potential to reduce foreign currency lending - in the riskiest segments, no less. It is possible, however, that cross-border services could render this relatively easy to circumvent as well. The question remains, on the other hand, whether this counter-argument is valid for commercial clients.
- *Asset-side liquidity ratios:* stipulating the holding of specific assets as a percentage of the balance sheet total, short term liabilitites or own funds. This raises the cost of lending on the one hand and also helps promote holding a larger liquidity buffer, which in turn increases the ability to withstand shocks. It does, however, have a negative effect on growth, as it requires the holding of liquid assets in the place of loans.
- *Regulation of maturity matching:* prevents excessive dependence on short-term financing, which could raise the costs of lending. This kind of regulation forces banks to develop healthier balance sheet structure, which reduces financing risks. It only limits excessive lending if term premia are large enough.

4) Fiscal instruments:

- The most obvious possibility within this set of instruments is the *taxation* of unhedged foreign currency lending. This renders the loan type more costly and less attractive. One disadvantage, however, is that it diverts funds from the institutions carrying out the risky activities, further deteriorating their financial situation.
- Revoking *government subsidies* related to lending for these loan types. Such a step would raise the cost of loans compared to earlier levels and thus has

real potential to reduce lending activity. This would have been difficult to implement from a political perspective.

We have now seen that the palette of potential instruments with which it would have been possible to attempt a reduction in excessive foreign currency lending in Hungary is very diverse. Although there are disadvantages associated with each instrument which served as counter-arguments to regulation, these are not always convincing. While the applicability of monetary instruments does not in fact seem high, certain prudential or fiscal instruments could have proved useful.

No significant regulatory steps were taken in Hungary prior to the crisis. Decision makers took negative short term growth effects into consideration with more weight than long-term advantages. Starting from the 2004 stability report, Magyar Nemzeti Bank regularly drew attention to the risks associated with foreign currency lending and advocated for the publication of a joint communication regarding the risks of yen lending. This was ultimately published relatively late, at the dawn of the crisis.

Among the neighboring countries, impacted by foreign currency lending, both Romania and Poland made stronger attempts to impede the proliferation of lending in foreign currencies. Romania - at that time not yet a member of the EU and thus much less restricted in regulatory issues - tightened regulation on provisioning in case of foreign currency loans, taking into account additional risk stemming from exchange rate fluctuations. In 2004, Romania introduced an upper limit to the LTV (loan-to value) measure, prohibiting lending with an LTV of over 75 percent. Further, in 2004, the country became the first to introduce a 30 percent limit to payment-to-income ratio in case of consumption loans, and, one year later, also introduced a 40 percent upper limit to the same measure for mortgages. Finally, Romania also employed monetary policy instruments to attempt to mitigate the risks of excessive foreign currency lending. The central bank raised the reserve ratio for foreign currency liabilities to 35-40 percent in the period between 2004-2006, while the ratio for leu-denominated liabilities decreased to 16 percent from 18 percent (Borio et al. (2007) - to compare, by this time, the reserve ratio in Hungary was already uniformly 5 percent, independent of denomination). The Romanian Central Bank’s Report on Financial Stability deemed these interventions successful, as they succeeded in putting a stop to the steady

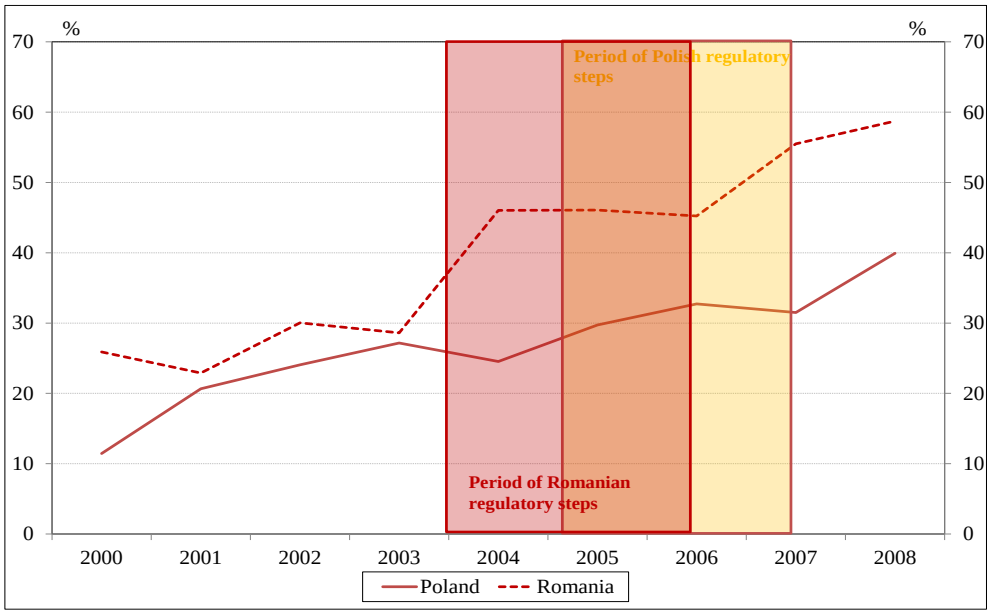
increase in the proportion of foreign currency loans within all commercial loans (NBR 2006).

Supervisory policy in Poland made significant efforts to curb the proliferation of foreign currency lending as well - also prior to joining the EU - although in this case, the deceleration of the expansion of foreign currency lending was also a positive side effect of monetary policy. As we saw earlier, the zloty weakened significantly in the period between 2003-2004 as a result of the reduction of the central bank rate. As Hudecz (2012) writes: "The actions of the monetary authority may played a role in the volatility of the zloty and, consequently, in the decrease in demand for foreign currency loans as well. The Polish central bank certainly did not intervene on foreign currency markets to reduce exchange rates fluctuations (there were in fact no foreign currency interventions from 1998 to September 2011)." Polish authorities took a number of further actions. Starting in the early 2000s, they gradually tightened capital regulations relating to foreign currency lending. Beside the capital requirement on lending risk, they also raised capital requirements on market risk, increasing due to exchange rate risk, rendering foreign currency lending more costly for banks. As part of a set of softer interventions, the supervisory authority constantly monitored the stock of foreign currency loans and demand for foreign currency loans separately, while also placing particular emphasis on resulting risks during bank stress tests (Borio et al. 2007). Meanwhile, the so-called S-recommendation published by the supervisory authority, which recommended tightening bank risk assessment regulations as well as providing borrowers thorough information, also may have had an affect on the deceleration of foreign currency lending (Hudecz 2012).

The examples of Romania and Poland demonstrate that while regulatory intervention is by no means a secret weapon against foreign currency lending, such steps do have the potential to limit the rate and extent of its growth. The dynamics of the proportion of foreign currency loans confirm this. Some deceleration in the expansion of foreign currency lending was visible in case of both countries (*Chart 14*). This is why, although all interventions have disadvantages and can be evaded, it is prudent to take such action. While this only pulls some small "brakes", these "brakes" help slow down negative processes.

This did not happen in Hungary, however, which is how the major risks we discuss in the following chapters were allowed to emerge in the banking system.

Chart 14: Evolution of the proportion of commercial foreign currency loans in all credit in Romania and Poland



Source: central banks and own calculations
Note: exvhange rate adjusted (basis 31 December 2008)

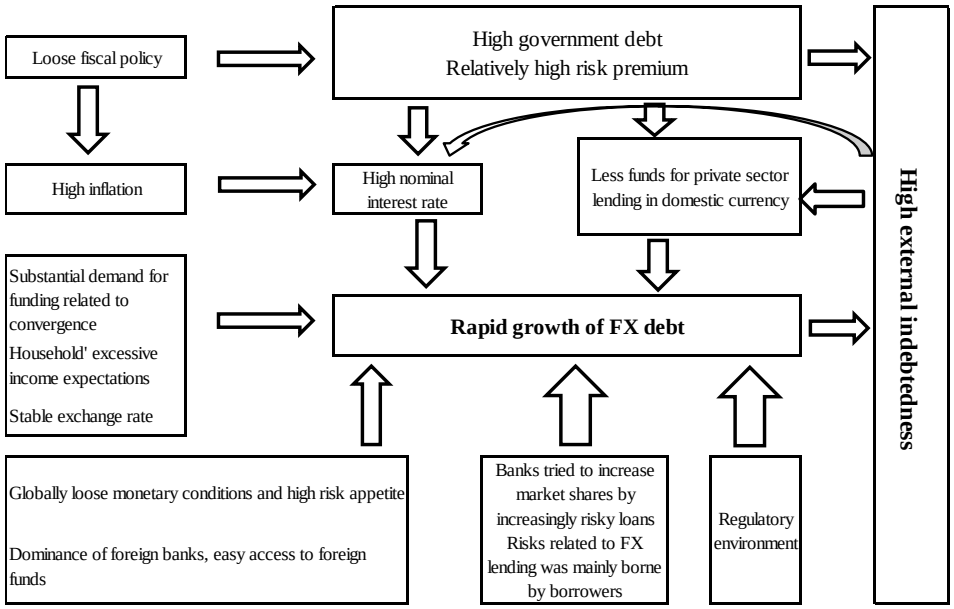
1.2.4 Conclusion

Chart 15 provides a good summary of which factors in particular led to the proliferation of foreign currency lending in Hungary. Government debt and external debt, increasing as a consequence of loose fiscal policy, increased Hungary's overall riskiness, which, in turn, resulted in high nominal forint interest rates. This was exacerbated by the fact that the inflation rate was high even in regional comparison, also due, at least in part, to fiscal expansion. Furthermore, high government debts led to a decrease in forint financing available for lending to the private sector, consequently it was an obvious choice for banks to raise foreign funds. They were able to do this, as the majority of the banking system was under foreign ownership, thus access to foreign financing was unhindered prior to the onset of the crisis.

This was further supported by the global abundance of liquidity as well. Foreign currency lending was also driven, from the banks' side, by the fact that banks' exchange rate positions remained closed, meaning they did not directly bear the risks stemming from any

potential fluctuations of the exchange rate. Their risks were further tempered by the fact that they predominantly issued loans with real estate collateral. From the demand side, stable exchange rates compounded with a significant interest rate differential increased the demand for foreign currency loans. Facing constant inflation pressure, the central bank strived to keep the forint exchange rate stable with interest rates higher than average for the region. Thus, economic actors basing their decisions on historical data had every reason to underestimate any potential weakening of the exchange rate. Finally, general optimism regarding the country's convergence was also an important factor. Even after the onset of the crisis in 2008, the general assumption was that the country would be able to achieve stable 3-4 percent growth, and consequently, repaying loans would not be an issue. Altogether, what we see is that the Hungarian economic policy mix was particularly favorable for foreign currency lending.

Chart 15: Process diagram of foreign currency lending



Among the region's other countries, Slovakia and the Czech Republic were both able to reduce interest rates to relatively low levels as their foreign debt was not high and they were not plagued by high inflation. On the other hand, in Poland, proliferation of foreign currency lending had already begun by the dawn of the 2000s, driven by relatively high debt and high interest rates due to inflation. The monetary policy reform of 1998 was,

however, able to significantly decrease inflation and, starting in 2002, the Polish central bank was also able to decrease the central bank rate considerably. It is important to note that this was also reinforced by Polish fiscal policy, which did not allow government debt to increase. Finally, they also implemented a number of interventions to decelerate the proliferation of foreign currency lending. The Romanian economy displayed the worst performance of all the countries examined, which in itself increased its overall riskiness. Meanwhile, they were constantly plagued by very high inflation, thus interest rates on foreign currency loans were also more favorable here than those of loans denominated in the domestic currency. As a consequence, by 2004-2005, half of all household loans were foreign currency loans. Romanian authorities did, however, attempt to curb the proliferation of foreign currency lending through regulatory interventions. Meanwhile, balanced fiscal policy made it possible for the central bank to steadily reduce the central bank rate and thus increase demand for leu loans.

1.3 Risks and their consequences

1.3.1 Risks stemming from foreign currency lending

We focused on the factors contributed to the proliferation of foreign currency lending from the macroeconomic and economic policy side in the previous subchapters. It is obvious that the high external indebtedness, the optimistic growth expectations, loose regulatory environment, the ownership structure of the banking system and global li-quidity conditions together supported the expansion of FX lending. But what impact may FX lending has on the bank-ing system and the real economy? And what damage may it cause on a longer horizon?

From social and economic point of view, one of the most important problems with FX lending to households or SMEs and exchange rate risk is run by actors who are not able to manage it. Moreover, mostly they do not even know the risk they run. As a result, probability of default in case of FX loans is usually higher than that of domestic currency loans. It is not clear for borrowers how volatile the exchange rate movement can be so they are not prepared for it. Favorable instalments stemming for lower interest rate let borrowers to get indebted more and in many cases use this opportunity.

In addition to higher credit risk, FX lending may result higher liquidity risk as well. Savings of private sector are usually denominated in local currency which means that deposit base of the banking system i.e. the most stable funding source is denominated in local currency. FX liquidity for FX loans then should be ensured in a different way. It can be in the form of relatively stable long term interbank loans or bonds but it may be short term interbank loan or different types of off-balance sheet contracts (e.g. forwards, FX swaps etc.). Reliance on these latter types is risky since these markets may stop operating in crisis periods.

Huge losses may stem from these types of risks in unfavorable macroeconomic and financial environment. Due to the depreciation of local currency instalments of FX loans increase significantly so those customers who could expand their debt due to the favorable conditions of FX loans may default. It also result social tensions since real estates serving as collaterals of mortgages can be repossessed by the banks. Turmoil on interbank market is also very prob-lematic for the banking system. Rolling over of maturing contracts may be very expansive or some banks may not meet their obligations.

These risks erode profits of banks due to high cost and losses. As a consequence even bank defaults may occur. Those banks which face these risks have to adjust their balance sheet and it mostly means a lower lending activity. At the end the lack of lending has a negative impact on the performance of the real economy.

1.3.2 Examination of the consequences of FX lending

In the previous section, some factors were summarized which may enhance the riskiness of lending when it is de-nominated in FX. The five papers presented in this dissertation aim, based on these factors, to explore what risks existed in the Hungarian banking system due the expansion of FX lending. A detailed analyzes will be presented on the risks built up before the onset of the crisis. We analyze whether FX lending caused higher credit and liquidity risks in the banking system or not. Crisis effects will be also explored and long term impacts will be examined as a final step.

Chapter II is, in a sense, the continuation of this introduction, as it focuses on the risks that emerged in the banking sector as a consequence of the proliferation of foreign currency lending prior to the onset of the crisis. Additionally it also presents in brief the issues credit

institutions had to face at the very beginning of the crisis as a consequence of these risks. The study highlights the fact that both liquidity and lending risks increased significantly in the Hungarian banking system due to the lending expansion that took place before the crisis. Right after the onset of the crisis, liquidity issues rendered central bank intervention necessary, particularly on FX swap markets. Following the manag-ing of immediate issues, however, the banking sector embarked on a necessary process of readjustment to mitigate previously accumulated risks. Meanwhile, a significant reduction in lending aggravated other issues in the real econ-omy.

Chapter III centers around one specific example of the risks enumerated before, liquidity risk, more specifically pro-cesses observed on FX swap markets. Expanding an earlier study (Banai et al. 2013) focusing only on the short FX swap market, it draws conclusions based on the network structure of the FX swap market as a whole, as well as its submarkets defined by maturity range. One important observation is that networks derived from the FX swap market all behave similarly to the networks of the unhedged interbank market. This means that although FX swaps represent hedged transactions, the significant liquidity risk makes actors react equally strongly to any exogenous shocks. In other words, dependence on FX swap markets is also a source of serious risk within the banking system. Examination of financial networks has relevance in practice (a good summary is given by Balog et al. 2012 or another aspect is presented by Csóka and Kiss (2015)). This paper expands the literature by investigating a specific market.

Chapter IV details another source of risks, credit risk. Based on a survey of households holding debt, it explores which factors influence households' probability of bankruptcy and in what way, as well as how this information can be used to optimally regulate the PTI (payment-to-income) measure. We constructed a logit model to examine these questions. Our results show that households' income and labor market situation, level of indebtedness, and the denomination of the loan and manner of borrowing all impact credit risk. This analyzes prove that FX borrowers indebted more than HUF borrowers due to lower initial debt service. It also suggests that probability of default was higher in case of FX borrowers than that of HUF borrowers.

Following the presentation of the main risks, in Chapter V, we go a step further and explore the factors defining the lending activity of individual banks within the Hungarian banking system. We pay particular attention to the various levels of liquidity risk. Results of the panel regression constructed to support our examinations show that liquidity position is particularly relevant in the lending activities of Hungarian banks. The larger a bank's liquidity risk, the less it was able to lend. Following the onset of the crisis, however, adequate capitalization also began to play an increasingly important role in lending activity beside liquidity. An additional important result is that ownership structure in itself does not influence lending, but the owner's income, capital and liquidity positions do have a significant impact on the behavior of the Hungarian subsidiary.

Finally, Chapter VI expands the analysis presented in Chapter V. Contrary to the other sections, its scope is not limited to Hungary, but instead focuses on the banking systems of the 11 states of Central and Eastern Europe, particularly on the lending activity of banks in foreign ownership. It is visible from the results of the panel regression that one of the most important factors affecting lending is the proportion of non-performing loans within the portfolio. Further, results show - in line with the study of the Hungarian banking system - that the state of foreign parent banks has high relevance in terms of the activities of the region's banks. Prior to the crisis, subsidiaries of banks with riskier operations were more active in the CEE region, as high profitability was the main priority. After the crisis, however, emphasis shifted to mitigating risks, and subsidiaries of parent banks in better liquidity positions or themselves enjoying adequate capitalization began to lend more.

2. THE DEMISE OF THE HALCYON DAYS IN HUNGARY - ('FOREIGN' AND 'LOCAL' BANKS – BEFORE AND AFTER THE CRISIS)[5]

After the Lehman collapse, the financial crisis hit Hungary hard. Long lasting turmoil in the financial system was followed by a deep recession. Effects of the crisis and th role of the banking system in them were analysed by several papers. Liquidity problems were especially serious in the first phase of the crisis due to the high reliance on external funds both characterizes both the country and the banking system. Recession eroded banks' credit portfolio and increased significantly the probability of defaults. Our paper examines the evolution of the banks before the crisis and their crisis history until mid 2009 from a special point of view. We analyse this period by distinguish between banks owned by strategic foreign parents ('foreign banks') and others considered as 'local banks'.

Journal of Economic Literature (JEL) code: E44, G01, G20, G21.

[5] This paper was published in Hungarian as: Banai Ádám, Király Júlia, Nagy Márton: Az aranykor vége Magyarországon. Külföldi szakmai és lokális tulajdonú bankok – válság előtt és válság után. Közgazdasági Szemle, LVII.. évf., 2010. február (105-131. o.). It was also published in BIS papers series in English: Banai, Ádám, Júlia Király and Márton Nagy (December 2010): The demise of the halcyon days in Hungary: 'foreign' and 'local' banks – before and after the crisis, BIS Papers No. 54, December 2010

Banks owned by foreign strategic owners have been present in Hungary since the middle of the 1980s, and as a result of the large-scale bank privatisation in the mid-1990s, the lion's share of the Hungarian banking system was acquired by foreign strategic owners. The effects of this process have been the subject of numerous previous studies. Ábel and Szakadát (1997) focused on the structural transformation of the banking system in the 1990s and the related costs. The authors conclude that the transformation of the banking system was overall successful, but that its pace was too sluggish, leading to additional costs. Hence, had large banks been pushed into carrying out structural transformations at the very beginning of the 1990s, consolidation costs would have been lower. Várhegyi (1998) examines the Hungarian banking system's ownership structure. The study comes to the major conclusion that by allowing foreign banks entry and participation in bank privatisation, the Hungarian banking system's operation resembled that of developed countries in many of aspects by the end of the 1990s. Mérő and Valentinyi (2003) reached a similar conclusion, having examined the role of the appearance of foreign banks in the Central and Eastern European region. Várhegyi (2002) explains the banking system's development following the transition in details by presenting the transformation and business strategy of individual banks. Király, Mérő and Száz (2007) examine the Hungarian banking system's corporate governance structure. The study reveals that the murky, fragmented nature of state ownership is the source of severe management problems.

Numerous studies have also been written on the Hungarian features of the 2007 crisis and its effects on the banking system. From October 2008 following the collapse of Lehman Brothers, Hungary was affected by a severe financial/liquidity crisis, which threatened to paralyse the entire financial system, followed by a deep recession. The Hungarian banking system's reaction to the global financial and economic crisis has also been presented from numerous perspectives. Király, Nagy and Szabó (2008) deal mainly with contagion channels, highlighting the role of risk premia and two-way contagion channels between parent banks and subsidiaries. Várhegyi (2008) attributed Hungary's and its banking system's high vulnerability to external balance problems and substantial credit expansion. Király (2008) presents the Hungarian banking system's pre- and post-Lehman period from a liquidity perspective. According to the study, the crisis must be prevented with restrictions and limitations in all cases where an apparent excess of liquidity leads to

irrational results, such as disproportionately high leverage, asset price bubbles financed by credit growth, and banking systems supported solely by external financing, operating with excessively high loan-to-deposit ratios. Banai, Király and Várhegyi (2009) analysed the behaviour of European banking groups exposed to Central-Eastern European region and concluded that against the foreign investors' fear the outflow in parent banks' financing remained modest during the crisis.

A number of studies have thus dealt with the effects of privatisation, the performance of banks acquired by foreign strategic owners and those having chosen other paths, as well as the effects of the 2007 crisis on the banking system[6]. However, to the best of our knowledge, this is the first paper which examines the asymmetries in the behaviour of the two main strategic groups of Hungarian banks in the pre- and post Lehman period.

From the perspective of the events which occurred in Hungary, we consider October 2008 as the starting point of the crisis. We will compare the performance of two groups of banks. The '*foreign banks*'[7] group includes institutions in which *foreign strategic investors acquired majority ownership* primarily in the course of privatisation in the 1990s. *'Local*

[6] Banking system includes all the banks, branches and specialized financial institutions except for Keler, MFB, Exim. Saving co-operatives and saving co-operatives transformed to banks (Dél-Dunántúli Regionális Bank, HBW Express Bank, Kinizsi Bank, Mohácsi Bank) were left out of our focus due to their special corporate governance and business strategy.

[7] In the investigated period (1999-2009) the group of foreign banks included the following banks: Allianz Bank (it was Dresdner Bank until 2006), ABN Amro Bank (it was merged with Kereskedelmi és Hitelbank in 2001), Általános Értékforgalmi Bank (it has become an investment company in 2007 and got out of our focus), Banco Popolare (former IC Bank), Bank of China, Bank Plus Bank, Budapest Bank, Cetelem Bank, CIB Bank, Commerzbank, Credigen, Deutsche Bank, EB und HYPO Bank Burgenland Sopron, Erste Bank, Fundamenta Lakástakarékpénztár, Hanwha Bank, Inter-Európa Bank (it was merged with CIB in 2007), KDB Bank (former Daewoo Bank), Kereskedelmi és Hitelbank, Magyar Külkereskedelmi Bank, Opel Bank (it has become a financial enterprise in 2002 and got out of our focus), Porsche Bank, Rabobank (it has become a financial enterprise in 2002 and got out of our focus), Raiffeisen Bank, Société Générale Bank (it has become a financial enterprise in 2002 and got out of our focus), Unicredit Bank (HVB Bank before 2006 which was established as a merger of Hypovereinsbank and Bank Austria Creditanstalt), Unicredit Jelzálogbank (HVB Jelzálogbank until november 2006), Volksbank, Westdeutsche Landesbank. The group of foreign banks also includes the following foreign branches: Axa Branch (former Ella, then Axa Bank), Banco Primus Branch, Bank Sal.Oppenheim, BNP-Paribas Branch (former BNP-Dresdner then BNP-Paribas Bank), Calyon S.A. Branch (former Credit Lyonnais then Calyon Bank), Citibank Branch (former Citibank), Cofidis Branch, Fortis Branch, ING Branch (former ING Bank), Oberbank Branch.

banks'[8] include banks held in majority by *domestic (state) investors*, or held in shares scattered among owners *on the stock market*, i.e. where privatisation by foreign strategic investors was avoided. We are aware of the fact that 'foreign' and 'local' groups are both highly heterogeneous,[9] but this analysis does not aim at elucidating this heterogeneity, focusing instead on the differences in behaviour between the two defined groups.

The first half of the study examines in detail the performance of banks from the end of the 1990s until the onset of the financial crisis in October 2008. At the beginning of the new millennium, increasing retail credit market competition[10] among foreign and local banks determined the similarities or differences in strategy. 'Local banks' began their expansion in Eastern Europe at this time, thereby competing with not just the subsidiaries, but also with the parent banks of 'foreign' banks'. In this period the balance sheets of the two groups were characterised by rapid credit expansion, high profitability and the emergence of liquidity and credit risks.

In the second half of the study we focus on the divergent behaviour of banks during the crisis. Following the October 2008 crisis, every bank faced a radically altered financial and macroeconomic environment, and had to adapt to the new conditions. Regarding this period, we concentrate on examining whether the different ownership structures and the various pre-crisis strategies required diverse crisis management practices.

2.1 'Foreign' and 'local' banks before the crisis

The consolidation of the banking system during the transition and the establishment of market-based operation were part of Hungary's economic transformation. While the

[8] In the investigated period (1999-2009) the group of local banks included OTP Bankgroup (OTP Bank, OTP Mortgagebank, Merkantilbank, OTP Lakástakarékpénztár), FHB Bankgroup (FHB Mortgagebank and FHB Bank), the Postabank (until 2004), Magyar Takarékszövetkezeti Bank and ELLA Első Lakáshitel Kereskedelmi Bank. Despite the small number of banks the overall market share of this group exceeded the 30 per cent of the total asset of banking system in 2008.

[9] Privatisation unquestionably represents a behaviour change in a bank's operation: nevertheless, we consider the difference between banks owned by foreign strategic owners and those without such ownership more significant than the one between state-owned banks and those with ownership dispersed through the Hungarian stock exchange.

[10] We mainly focus on the retail market, and only touch upon the development of the corporate market.

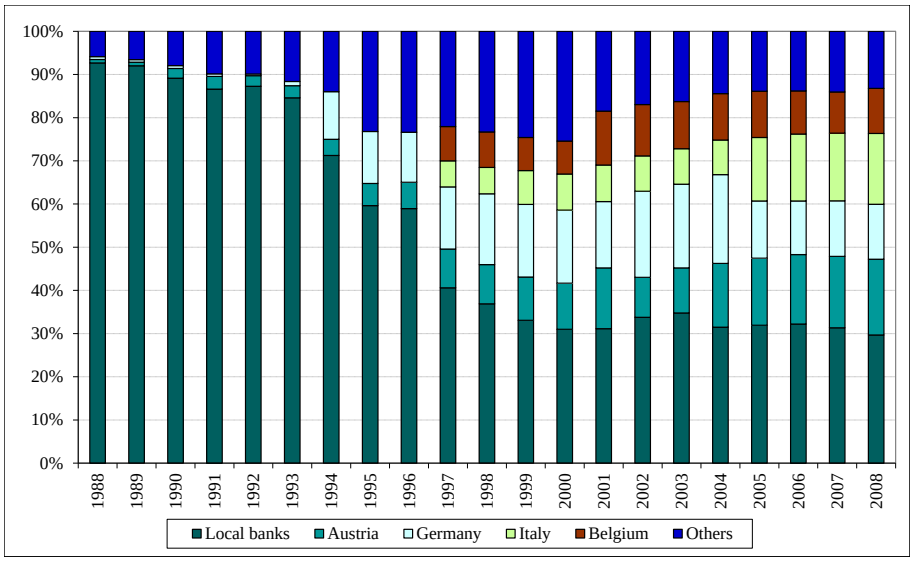
institutional framework of a market economy was established, the earlier one-tier banking system was transformed into a two-tier system as part of the market reforms, while more and more foreign strategic owners were entering the market and the proportion of non-directly state-owned banks was increasing.

2.1.1 Retrospection: the evolution of the current ownership structure

In 1990 the proportion of foreign strategic ownership in the Hungarian banking system was a mere 5 per cent, although it was constantly rising with the successive entries of 'greenfield' – primarily Austrian, Italian, German and Benelux – banks. Nevertheless, mass privatisation only got underway after the collapse of the banking system in 1993.

The state loan, debtor and subsequent bank consolidation programmes after the 1993 bank crisis somewhat improved the portfolio and capital position of majority state-owned credit institutions. The fact that state assets were insufficient for managing the accumulated problems (Ábel and Szakadát, 1997) facilitated the acceleration of the privatisation process from 1994. Privatisation with the participation of *foreign owners* was a necessity, arising from the deficiency of internal capital accumulation (Szapáry, 2001). On the other hand, sales to foreign *strategic investors* were justified by the anticipated 'knowledge import'. After the turn of the millennium, the ownership share of foreign banks in the Hungarian banking system reached a level of around 70 per cent. *(Chart 16)*

Chart 16: Developments in the ownership structure of the Hungarian banking system

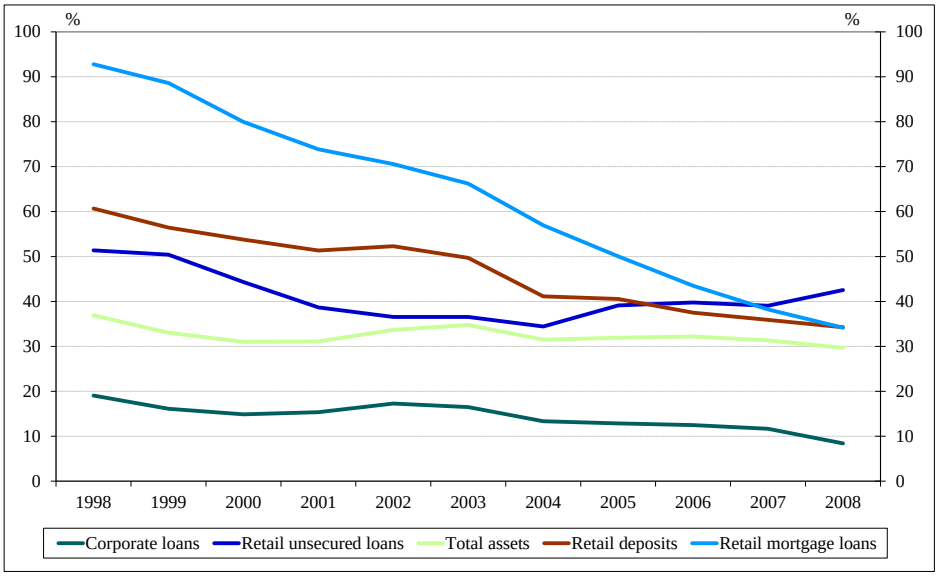


Source: MNB. Note: We considered the OTP Group as entirely domestic-owned.

Expansion towards the East was part of Western European banks' long-term strategy during the era of mass privatisation. The basic assumption was that Hungary, after getting through its transformation crisis, would continuously converge with Western European countries, and display rapid economic growth and thus rapid revenue growth. At the outset, foreign banks primarily appeared in the corporate segment, which required a lower initial investment, and did not represent fierce competition in the retail segment until the turn of the millennium (Móré and Nagy, 2004). The entry of foreign banks into the retail segment was limited by numerous factors besides the inherited competitive edge of local banks. One such entry barrier was information asymmetry, which characterised household lending due to the short credit history of Hungarian households. This problem affected local banks to a lesser extent, as their continuous participation provided them with far more information about customers. The other important factor lies in the special needs of the household segment. In order to reach and adequately serve the potential clients, there is a need for a much more extensive branch network and staff than in the case of the corporate segment. The associated high costs prevented foreign banks from entering this market or strengthening their presence for a long time.

Due to the retail market's high entry costs, foreign banks initially focused on the corporate segment. Expansion in the corporate segment was supported by the arrival of multinational firms, the appearance of similar 'home-host' relations in the corporate segment and an upswing in external trade. Moreover, foreign banks did not inherit low-quality corporate portfolios from the pre-transition period, they had experience in the field of commercial banking and could thus overall offer more favourable conditions to customers than their domestic competitors. *(Chart 17)*

Chart 17 Market share of local banks based on certain balance sheet items



Source: MNB.

Thus, foreign banks gained ground within the Hungarian banking system following the transition, first as greenfield investors, then as privatisers. The major players were the Austrian banks Raiffeisen, Erste and Creditanstalt, the Italian banks Intesa and Unicredito, the German bank BLB, and the Belgian bank KBC (and before that, the Dutch bank ABN Amro) group.

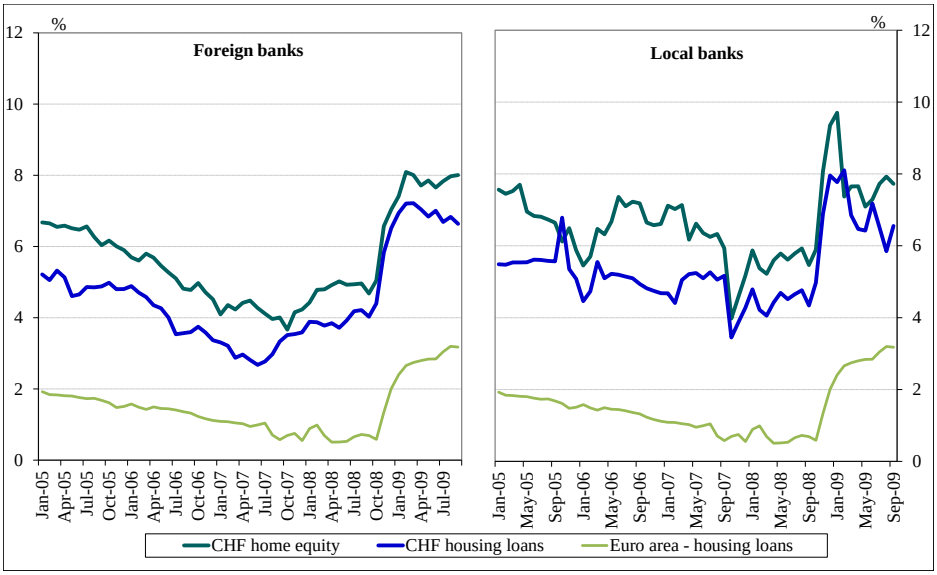
OTP, the 'national champion', however, was not sold to foreign strategic investors, but instead privatised in 1995 via an initial public offering on the stock market. FHB Bank, founded in 1997 and with a main profile of mortgage-backed lending, was also kept from foreign acquisition by being privatised on the stock market in 2003, similarly to OTP. These two banking groups became the most significant players between those banks which have never had a major strategic investor as their owner.

2.1.2 The credit boom on the retail market: non price-based competition

The end of the 1990s saw some change in the attitude of foreign banks. The profitability of the corporate segment began to dwindle due to fierce competition, so banks were more inclined to turn towards the retail segment. Meanwhile, households exhibited increasing demand for bank products as a consequence of improving income growth prospects.

Throughout the entire pre-crisis period, '*price-based competition'* between banks was low.[11] Although local banks applied higher interest in the case of loans and lower interest in the case of deposits than their foreign competitors, the banking system as a whole was characterised by oligopolistic pricing (Várhegyi, 2003, Krekó, Horváth and Naszódi, 2006, Horváth, Molnár and Nagy, 2007). Banks' behaviour may have been influenced by the fact that the Hungarian customers' price sensitivity was low (Horváth, Molnár and Nagy, 2007), and therefore price was not the most important factor in the acquisition of new customers. The business policy of banks was based on acquiring more customers at the price of higher costs or risks rather than by charging lower prices. This is supported by the fact that margins on retail loan products remained around twice as high as in the Euro area over the entire period. *(Chart 18)*

Chart 18: Interest premia on typical loans



Note: We deducted the 3-month CHF Libor from the APR of domestic retail mortgage loans, and deducted the 3-month EURIBOR from euro area housing loans interest rates.

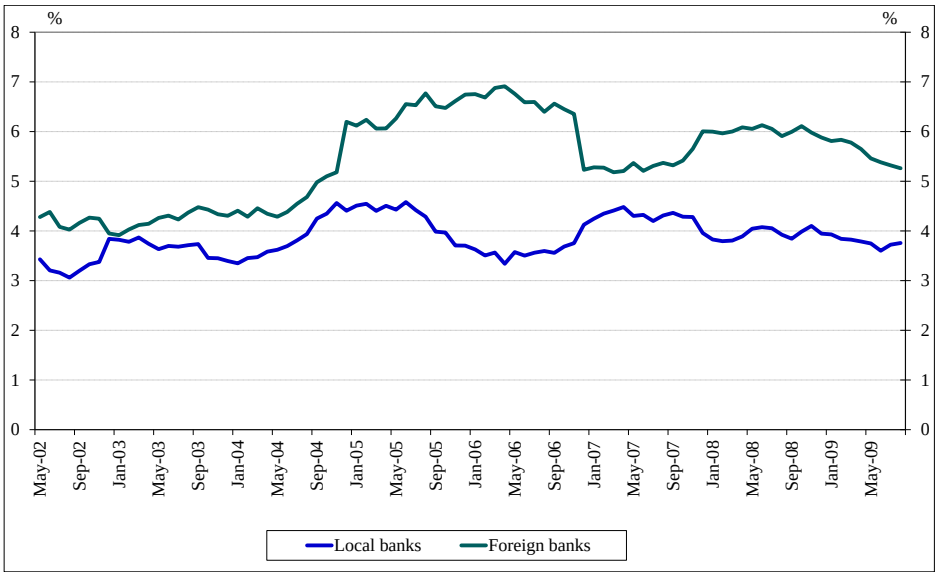
Source: MNB.

Therefore, a different set of instruments emerged in customer acquisition. In the first phase of competition, priority was given to the expansion of sales channels – banks' marketing

[11] At the beginning of the new millennium, HUF-denominated, state-subsidised housing loans were the major type of credit granted to households. The interest rate on housing loans and banks' interest margin were not set by market mechanisms, but rather by the rate of subsidy.

activity, networks and employee headcount thus grew substantially, just as the costs of this fast expansion. In this so-called *'cost-based competition'*, there was great discrepancy between local and foreign banks. Local banks had a competitive edge on the market compared to foreign banks, stemming from strong retail customer relationships, large branch networks and the establishment of mortgage banks. Mortgage banks refinanced banks within their group or other foreign banks. Thanks to this competitive edge, local banks did not take part in the rush to open branches, and continued operating with the same number of employees and network units. Moreover, although marketing costs increased substantially within this group as well, they nevertheless represented a much smaller proportion within local banks' operating costs in comparison to foreign banks. *(Chart 19)* Despite less active cost-based competition, the initial strong market position of local banks allowed them sustain their leading role in the competition of state-subsidised HUF loans.

Chart 19: Ratio of marketing costs to total operating costs

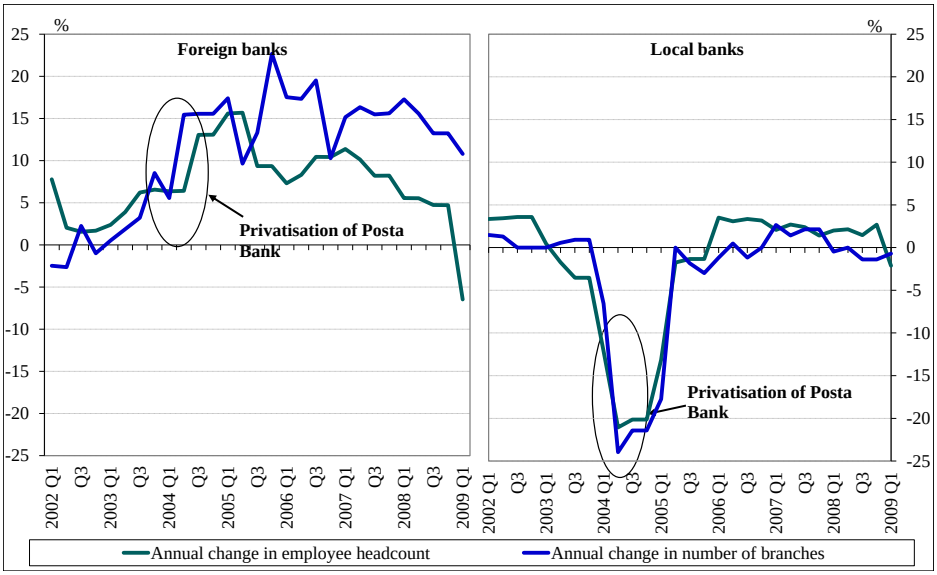


Source: MNB.

By contrast, foreign banks launched strong cost-based competition. Marketing costs rose sharply, and the number of branches and ATMs, as well as the number of employees increased. As competition intensified, foreign banks acquired substantial market share in

the mortgage loan segment, but did not succeed in dethroning local banks from their market-leading position.[12] *(Chart 20)*

Chart 20: Annual change in number of employees and branches



Source: MNB.

State subsidies of HUF-denominated housing loans were cut back significantly in 2003. Competition for retail customers thus took a new turn due to the drop in sales of HUF-denominated mortgage loan constructions. "*Risk-based competition'* emerged in parallel to *cost-based competition*. Risk-based competition triggered a shift towards increasingly risky products and customers. The first sign of this was the appearance of FX-denominated loans.[13]

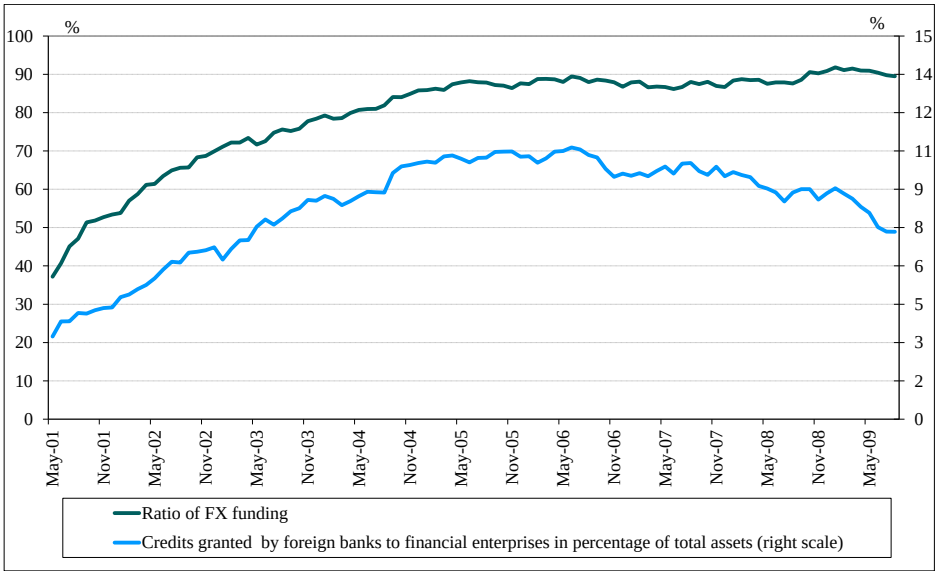
FX-denominated loans first appeared in 2001 in relation to financial enterprises, mainly in the field of vehicle purchase financing. The expansion of FX-denominated vehicle loans surfaced primarily among the financial enterprises of foreign-owned banks. Between 2001 and 2004, the ratio of financial enterprise financing compared to the balance sheet totals of owner banks tripled. By 2005, the ratio reached 11 per cent of the balance sheet totals at

[12] By increasing the number of branches, foreign banks obviously also strived to break into the deposit market, in addition to selling loan products. Although the costs of entry were the highest in this area, competition was also the lowest, therefore interest margins were the highest (Móré and Nagy, 2004).

[13] For further reasons behind FX-denominated lending in greater detail, see Bethlendi et al. (2005).

foreign banks, and despite the substantial rearrangement of bank balance sheets as a result of the retail credit boom, it remained at around 8 per cent prior to the crisis. *(Chart 21)*

Chart 21: Developments in credit granted by foreign banks to financial enterprises



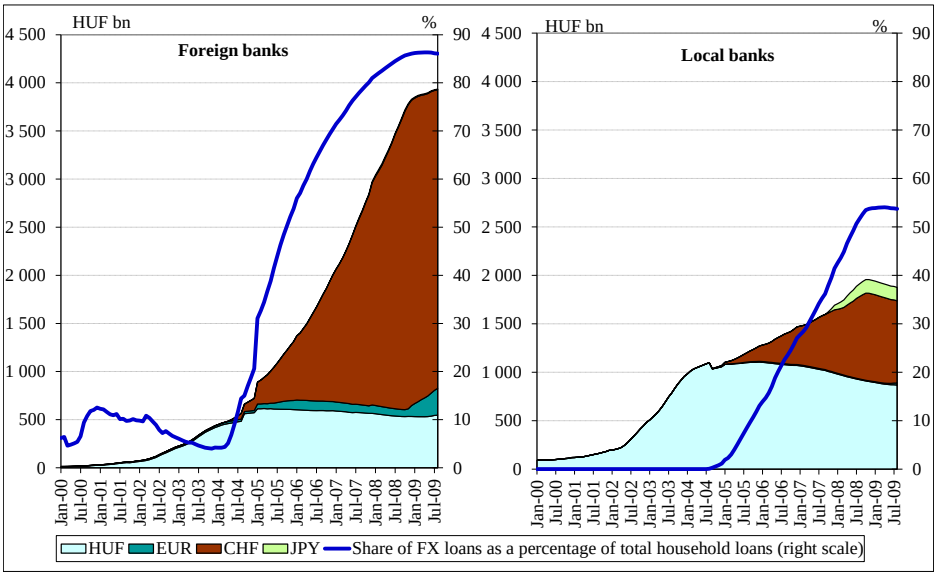
Note: The chart displays loans to financial enterprises as a percentage of bank's total assets and the denomination structure of this credit.

Source: MNB.

The popularity of FX lending did not remain confined to vehicle financing. With the drop in state-subsidised HUF-denominated housing loans, FX, particularly CHF-denominated financing became predominant among mortgage – initially housing, then home equity – loans from the beginning of 2004. Up to the onset of the crisis, these remained the main credit products of banks.

In the case of FX-denominated vehicle and mortgage loans, foreign banks were leaders, while local banks were followers. In retail mortgage lending, the ratio of FX loans began increasing as early as the beginning of 2004 among foreign banks, while this process only started at the beginning of 2005 among local banks. *(Chart 22)*

Chart 22: Currency structure of household mortgage loans



Source: MNB and authors' calculation

As one of the final chapters of risk-based competition, yen-denominated loans appeared as a new product already in the shadow of the crisis. While foreign banks were unequivocally the ones to push CHF-denominated collateralised loans, in the case of yen-denominated loans, the 'initiative' was local. Yen-denominated loans quickly became popular amongst households which were completely unaware of exchange rate risks, as these products were accessible with even lower instalments than CHF-denominated loans.

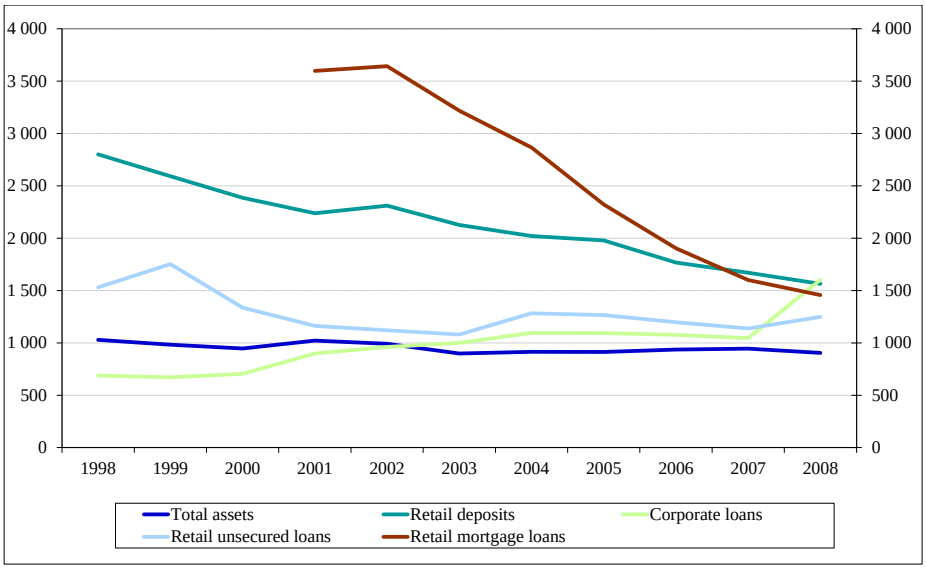
Besides the spread of FX lending, numerous other factors reflected the intensification of risk-based competition. Banks constantly eased their credit conditions and standards (MNB survey on banks' lending practices 2004-2008). The formerly conservative collateral requirements were constantly loosened, and banks applied high loan-to-value (LTV) ratios for an increasing proportion of loans.[14] Whereas at the end of 2004 the banking system's average LTV for housing loans was only 50 per cent, by the end of 2008 this ratio was approaching 70 per cent. Furthermore, several banks registered significantly higher payment to income (PTI) ratios (between 2004 and 2008, households' debt service burden to their income increased from 8 per cent to 13 per cent). Finally, in 2007-2008 banks relied

[14] Magyar Nemzeti Bank, Report on Financial Stability April 2007, April 2008 and October 2008.

increasingly on agents, a significantly more efficient sales channel compared to branches. More than 50 per cent of the mortgage loans granted in 2007 was sold through agents. Although agents significantly improved access to bank products, loans granted via their intermediation were characterised by two to three times higher default rates than those sold in branches.[15]

The *cost- and risk-based competition* discussed so far transformed the structure of the market. The substantial advantage of local banks in the retail segment eroded, while foreign banks gained ground. Over the past ten years, concentration among retail products fell most rapidly in the case of retail deposits and mortgage loans. In 2008, the HHI (Herfindahl-Hirschman Index) level of mortgage loans was only barely higher than that of the corporate credit market. *(Chart 23)* Nevertheless, local banks succeeded in reinforcing their leading market position, as their market share still surpassed 30 per cent in retail products.

Chart 23: Herfindahl-Hirschman Index for different segments of the Hungarian banking system



Note: In the case of collateralised retail loans, we consider the 2001 emergence of the market as the starting point.

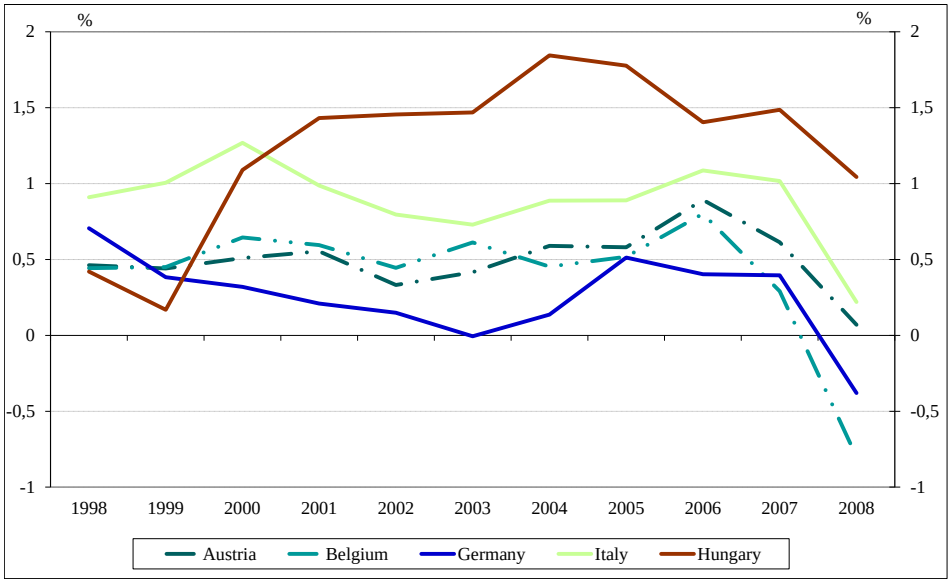
Source: MNB.

[15] Magyar Nemzeti Bank, Report on Financial Stability October 2008.

2.1.3 The consequences of high margins: high profitability, strong capital position

As a consequence of non-price based competition for customers and loan expansion stemming from economic growth, the profitability of the Hungarian banking system was considered outstandingly high over the past ten years, not only in the region, but in the whole of Europe. Foreign banks not only benefited from high profitability, but also contributed to the economic boom and to even higher profitability. The profitability of the Hungarian banking system surpassed the performance of that of the parent banks' countries by 50 per cent and in many cases, by as much as 100 per cent. *(Chart 24)*

Chart 24: ROA of foreign banks operating in Hungary and that of parent bank countries



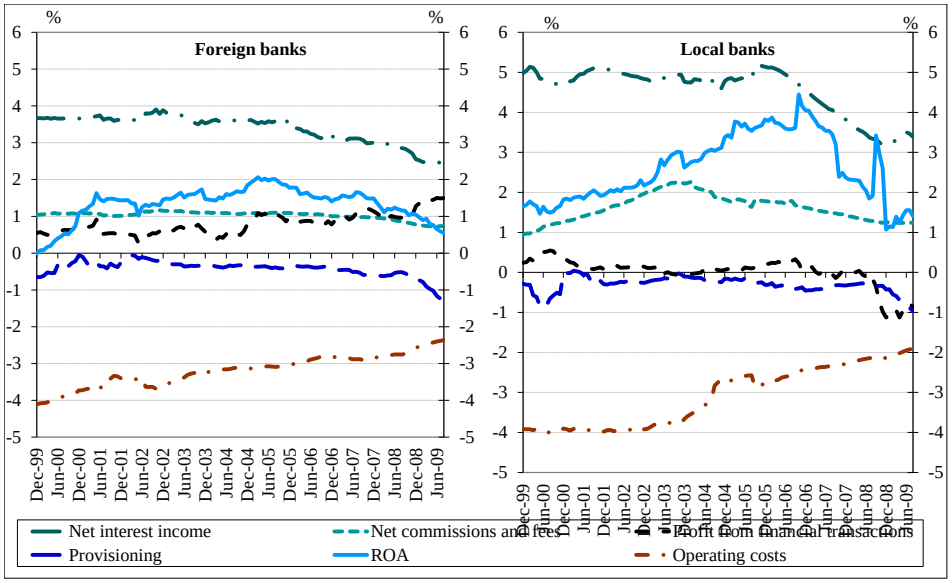
Source: OECD, MNB.

The profitability of the Hungarian and Western European banking systems differs not only in terms of scale, but also in terms of composition. Within the Western European banking system, the main source of revenue is non-interest income. In contrast, the main source of revenue in the Hungarian banking system is the high interest income stemming from high interest margins. The efficiency of the banking system and the result of financial operations are lower, while the portfolio risk and the resulting credit losses are higher than in bank groups of the euro zone countries.

In the course of the past ten years, the ROE and ROA of local banks were almost twice as high as those of foreign banks. *(Chart 25)* The ROE and ROA indicators – reflecting the profitability trend of the banking system – peaked at the end of 2004 in the case of foreign

banks and have gradually dropped since then. In the case of local banks, profitability only peaked at the end of 2005 at a very high level, and plummeted sharply thereafter. Local banks – whose profit advantages were mainly based on the inherited, very broad retail customer base – consistently outperformed their foreign rivals from the end of the 1990s. Thanks to customers' low sensitivity to loan and deposit margins, the higher margins and fee income realised by the local banks maintained a significantly higher interest and commission income level than that of foreign banks. Expensive account management fees and payment charges also contributed to the higher commission and fee income. The income difference was only slightly mitigated by the fact that the profit realised by foreign banks on financial operations was higher all along than that of local banks due to their more active treasury and custodian activities.

Chart 25: Relevant profit items to the total assets

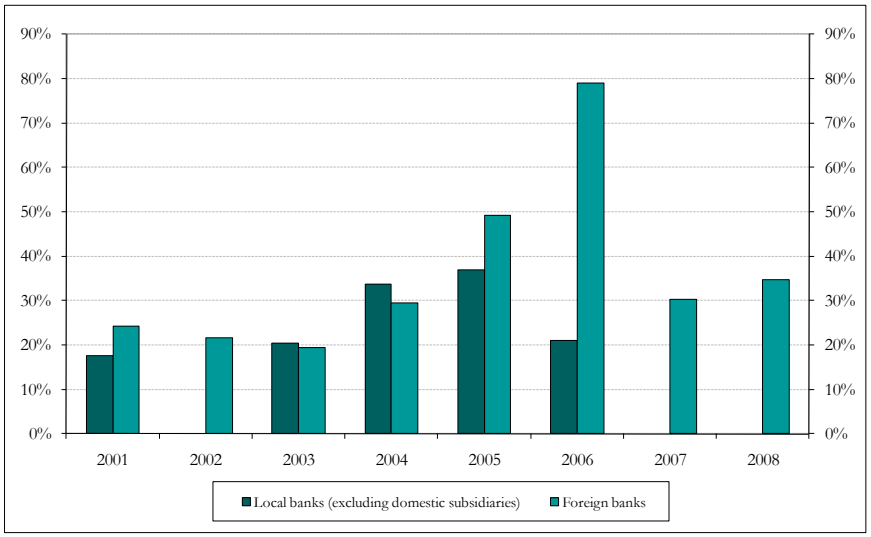


Source: MNB.

In terms of expenses, provisions at foreign and local banks were nearly the same over the past period. This is attributable to the fact that although the portfolio quality of local banks was better, their coverage with provision was significantly higher than that of foreign-owned banks, i.e. they calculated a higher provision for a better quality portfolio. For example, in the case of household loans, the coverage with provision of local banks exceeded 40 per cent, while the coverage of foreign banks was around 30 per cent in the third quarter of 2009. However, a significant change took place in the developments of

operating expenses in the course of the past ten years. While foreign banks' operating costs were higher than those of local banks until 2003, this relation reversed from 2004. The underlying reason can be attributed to the change in competitiveness. Since foreign banks gained more market share, local banks were forced to spend more and more on new technologies and the appropriate expertise ('negative spill-over effect') in order to improve their competitive position. This has largely contributed to the convergence of foreign and local banks' competitiveness. Later, though, the costs of foreign banks increased as local banks proved to be more competitive in selling retail products ('positive spill-over effect') thanks to their strengthened market position and extensive branch network. Foreign banks' budgets were heavily burdened by the expansion of their networks (both branches and ATMs).

Chart 26: Dividend payment rate



Source: MNB.

Of the profit realised in Hungary, 30-40 per cent was repatriated by foreign banks, boosting the profit of parent banks. The other part of the profit – 60-70 per cent *(Chart 26)* – was reinvested, which has largely contributed to subsidiary banks' sufficient capital adequacy and to sustaining their future growth and the resulting high profit level. The main source of the high capital adequacy of local banks was also attributable to internal capital accumulation. In the reviewed period the rate of reinvested profit was around 70-80 per cent.

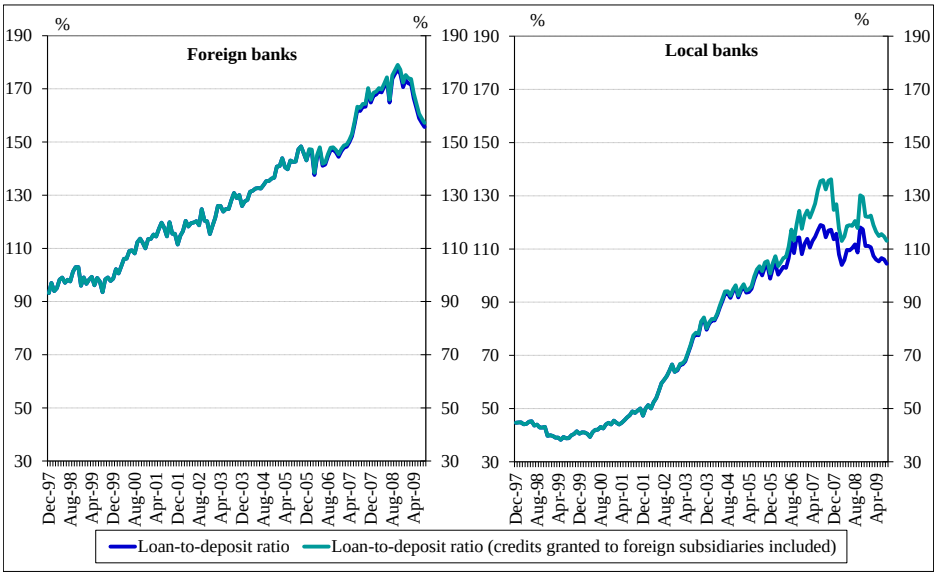
2.1.4 The price of sustaining high profitability: the emergence of liquidity and credit risks

The country's net foreign debt in percentage of GDP quadrupled in the past ten years. Due to the over-indebtedness of the public and the private sector net external financial requirement was significant in every year. The major part of foreign funds flowed in through the financial intermediary system. From these foreign funds, the banking system primarily financed the loans taken out by the private sector and, to a lesser extent, the budget's issuance of government securities. Government securities were financed for the most part by direct foreign purchases of assets.

In this period global money markets were characterised by ample liquidity, and cheap, easily accessible funding. At the same time returns realised on investments dropped substantially in the years preceding the crisis leading to hunting for yields and an increased risk appetite. One form of this was the Central and Eastern European expansion of banks, partly through capital investments and partly by the active refinancing of local affiliates. All of this essentially meant that over the past years, the savings of European parent banks acquired from the capital markets of different regions of the world financed Hungary's convergence and the rapid loan expansion entailed by strong non-price based competition.

Increasing funding risks are clearly indicated by the fact that while the bank loan portfolio of households nearly tripled between 2004 and 2008, their bank deposits increased by just slightly over 40 per cent during the same period. The loan portfolio of the private sector doubled in the same period, while deposits lagged much behind. Consequently, the loan-to-deposit ratio of foreign banks within the banking system already exceeded 100 per cent in 2000, and continued to rise sharply with the escalation of lending, peaking at 180 per cent at the end of 2008. *(Chart 27)* 60-70 per cent of the funds involved came from parent banks, while 30-40 per cent was raised on the capital markets. Due to their size and superior credit ratings, parent banks can have access to funds with better conditions, subsequently funding is centralised at many bank groups.

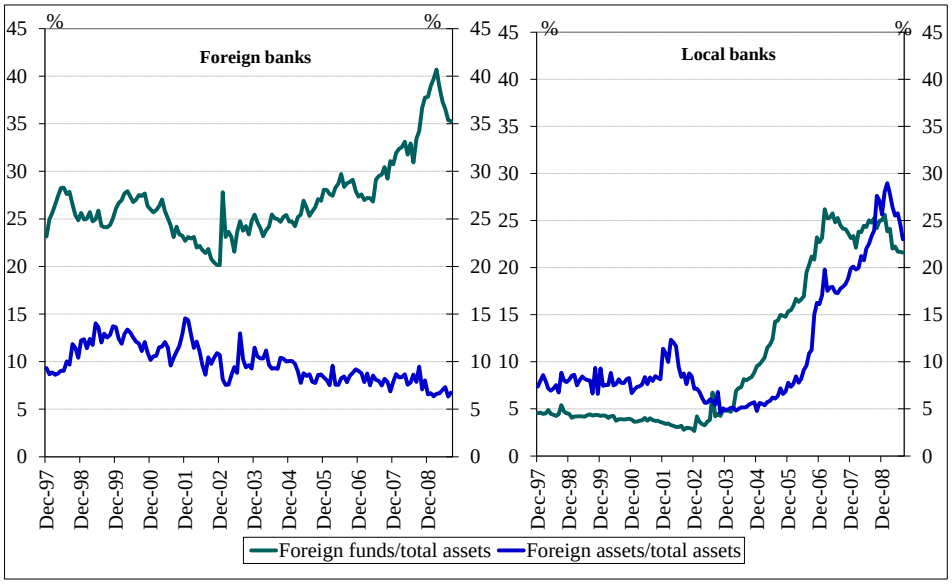
Chart 27: Loan-to-deposit ratio (exchange rate adjusted, basis 31 August 2009)



Source: MNB.

The loan-to-deposit ratio at local banks was still very low at the end of the 1990s, falling below 50 per cent. 54 per cent of retail savings was concentrated in this group of local banks, enabling them to finance the expansion of corporate lending until 2004 on from their existing, stable retail deposits, and subsequently to expand their vehicle loans and retail mortgages from 2000 through financial enterprises. However, deposit growth rate could not keep up with that of loans. Furthermore, the largest local bank set off its regional expansion at the beginning of the millennium. Hence, from 2004 local banks were also forced to increasingly turn to international funding. At that point, the loan-to-deposit ratio exceeded 100 per cent and continued to increase, peaking at around 130 per cent at the end of 2008. The L/D of local banks, exclusive of the funds provided for their foreign subsidiaries, only surpassed 100 per cent to a slight extent even in 2008 (being 110 per cent in December 2008).

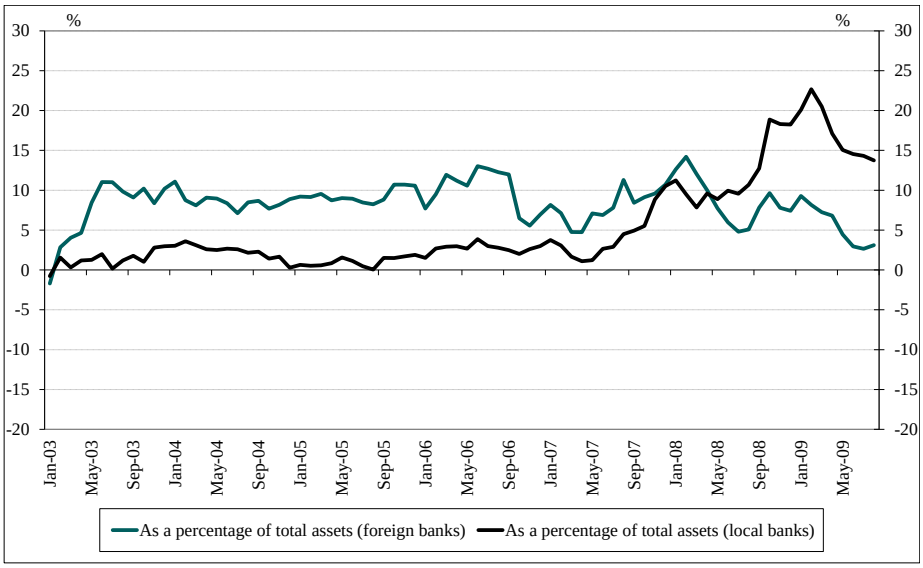
Chart 28: Ratio of foreign assets and liabilities to the balance sheet total



Source: MNB.

Accumulating huge amount of FX denominated assets *(Chart 28)*, banks did close their in the balance sheet open FX position with off balance sheet swaps. Between 2003 and 2007, the ratio of FX swaps to the balance sheet total fluctuated between 5-10 per cent at foreign banks, while for local banks, this ratio did not even reach 5 per cent, as right until the autumn 2007 they did not secure foreign currency by utilising their HUF liquidity through FX swaps, but rather by employing cheap and longer-term international funds. *(Chart 29)*

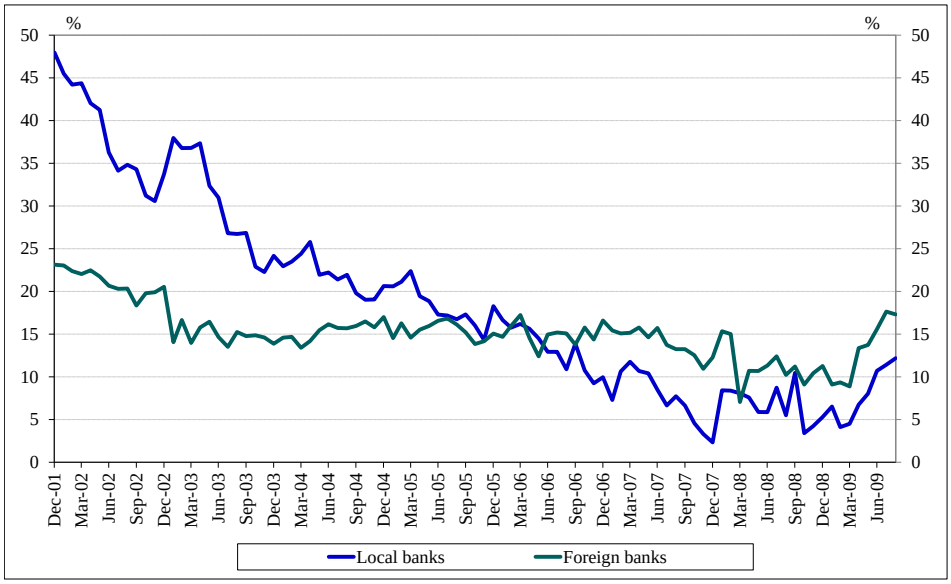
Chart 29: Developments in FX swap portfolios as a percentage of the balance sheet total



Source: MNB.

Finally, it was not only funding risks, but also asset side liquidity risks that increased. *(Chart 30)* As a result of credit expansion, the volume of liquid assets continuously decreased within the domestic banking system. This was especially evident in the case of local banks, where the ratio of liquid assets to the balance sheet total dropped from 50 per cent to 5 per cent between 2001 and 2007.

Chart 30: Ratio of liquid assets to total assets



Source: MNB.

Liquidity risks already became evident prior to the crisis in 2008. As a result of turbulences on the international money market in August 2007, cheap, longer maturity international funds gradually disappeared, and short-term money market swaps played an increasingly important role in the financing of FX denominated long-term loans through the utilisation of liquid assets.

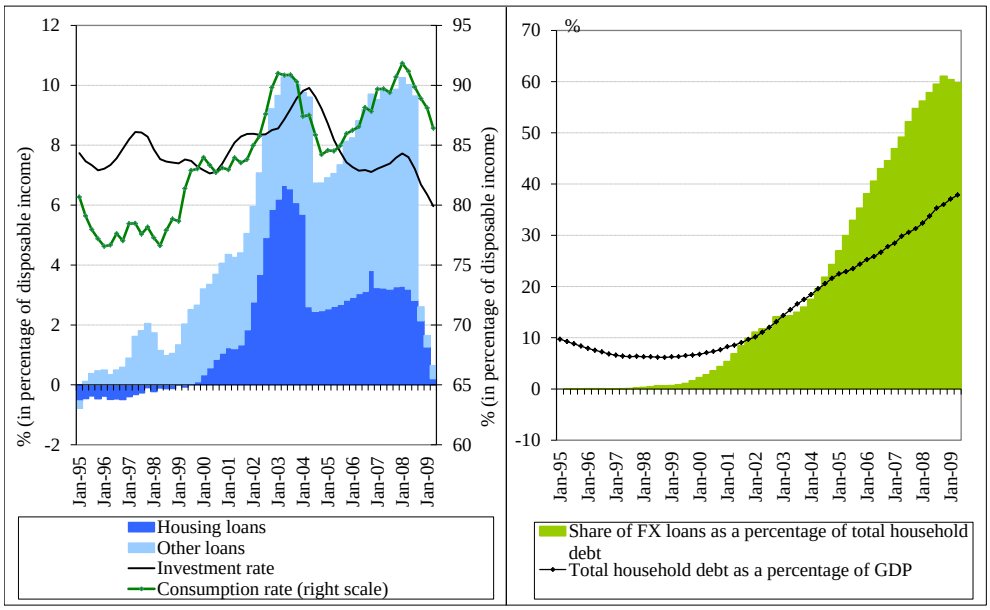
Non-price-based competition – with the objective of continuously expanding the market position – thus resulted in a strong increase in liquidity risks. On the one hand, as a consequence of a loan-to-deposit ratio considered high even by international standards, the banking system became increasingly reliant on international funds. International interbank funds are typically short-term and a less stable form of financing than retail deposits. All of this entails high renewal risk (‘maturity mismatch’). Moreover, as far as maturity mismatch is concerned, heavy reliance on the FX swap market also poses a key risk factor. In the event of disruptions on the international interbank market and on the FX swap market,

liquidity tensions may arise. Moreover, if a bank is unable to renew its FX swap deals, then the foreign currency should be purchased on the spot market which can in turn lead to substantial exchange rate fluctuations and a widening in the on-balance sheet net open position (on-balance sheet 'currency mismatch').

Although local banks' L/D was substantially lower than that of foreign banks, their renewal risk was nevertheless higher. On the one hand, foreign banks had access to parent banks' funding, with a stabilising effect due to the owners' long-term commitment. On the other hand, when the crisis unfolded, local banks had higher FX swap market exposures than foreign banks. Finally, the small liquid assets portfolio also increased the liquidity risks of local banks.

Due to the risk-based competition of banks prior to the crisis, not only liquidity risks, but also *substantial credit risks* accumulated, primarily on the retail market.

Chart 31: The correlation between retail lending and the main real economic aggregates characterising households and the developments in retail loan volumes



Source: MNB.

Over the past years the fact that retail customers' borrowings in FX had lax credit conditions and that exchange rates seemed relatively stable (concealing the actual exchange

rate risks) significantly contributed to the indebtedness of households ('retail capital mismatch'[16]). Excessive indebtedness is also reflected by the fact that the repayment burden of Hungarian households amounted to 13 per cent of their disposable income, while the consumption rate was above 90 per cent in 2008. *(Chart 31)* Both values exceeded the average for the euro area, while the ratio of retail loans to GDP (40 per cent) remained well below average. The high indebtedness ensuing from a lower household income path and a lower household savings ratio clearly indicates an increasing credit risk.

Credit risk is also generated by passed-on exchange rate risks (retail 'currency mismatch'). While in 2004, the household sector did not have any net open exchange rate positions, by the end of 2008 the sector's GDP-proportionate net position reached 20 per cent. As a result of this considerable open position substantial exchange rate depreciation would considerably deteriorate the portfolio of commercial banks, quickly turning the exchange rate risk of customers into credit risk of banks.

Over the last decade, the credit risks of both foreign and local banks increased substantially. Nonetheless, the credit risk level of local banks can be regarded as relatively lower, as suggested by the lower rate of loans in default for over 90 days.[17]

2.2 Adjustment in the crisis

As we have seen, the Hungarian banking system has generated an outstandingly high profit level over the past years. This high profitability was sustained at the cost of assuming increasing credit risks necessitate by risk-based competition and assuming increasing liquidity risks in order to fund this growth. These risks materialised as a consequence of the financial and the subsequent economic crisis, and it has become obvious that this high profitability cannot be sustained over the long run.

[16] IMF (2003): The Balance Sheet Approach and its Applications at the Fund.

[17] Local banks' regional expansion clearly increases lending risk. However, in this study we mainly focus on the domestic operation of banks as we would see a different picture on a group level in connection with the foreign banks present in Hungary.

The period following the outbreak of the crisis can be split into two clearly distinct phases: liquidity risks emerged in the first phase (final quarter of 2008), to be followed by credit risks in the second phase (2009-2010).

Although funding costs already started to increase in Hungary from August 2007 at the outbreak of the international financial crisis, and it was increasingly difficult to obtain long-term funding, we can only talk about liquidity crisis in the post-Lehman era, i.e. following the events of October 2008. As a result of the dramatic narrowing of financing opportunities, this financial crisis threatened Hungary with a crisis in its balance of payments, ensuing from the substantial public and private sector indebtedness. As a consequence of the country's significant need for international funding and the related extreme vulnerability, the exchange rate depreciated substantially as a result of the crisis, and key financial markets (mainly government securities, FX swap and interbank markets) dried up.

A number of prompt steps were taken in order to manage the liquidity crisis. To protect itself against an exchange rate attack, the central bank raised its base rate by 300 basis points while also deciding on taking a number of measures aimed at expanding liquidity and stabilising the market: it operated the swap market, assumed the role of lender of last resort both in HUF and in EUR, expanded the scope of acceptable collateral, announced HUF and FX credit tenders, cut its mandatory reserve rate, and continuously ensured that money markets remained operational. In order to ensure the state's financing and to replenish its diminished FX reserves, within three weeks the state reached an agreement with the International Monetary Fund and with the European Union on a EUR 20 billion loan package. All of this contributed significantly to the improvement of foreign investors' confidence.

The second wave of the crisis came in March 2009. During this period it was not purely a country-specific but rather a region-specific problem that emerged, prompting foreign investors to quickly sell their assets. Due to the substantial contraction of regional economies and the high proportion of FX lending, the banking system's credit losses increased sharply, which in turn increased the threat of financial instability. Due to uncertainties surrounding the state of the banking systems, the currency exchange rate of

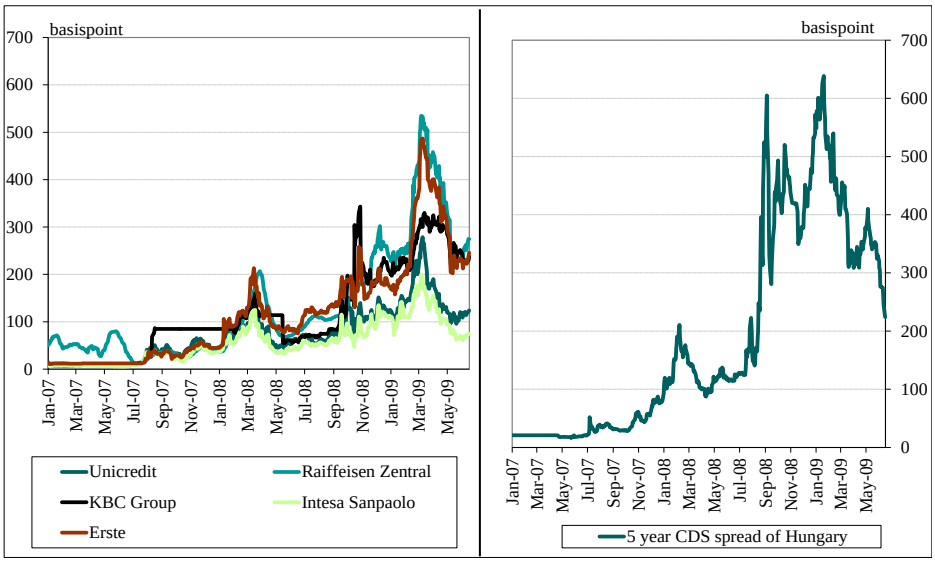
several countries depreciated substantially, while in the Baltic countries the likelihood of abandoning the currency board and the pegged exchange rate system posed a real threat. All of this resulted not only in a loss of investors' confidence, but also shook the confidence of households which manifested itself in the rapid, temporary outflow of deposits from the banking system. Confidence in Central and Eastern European countries was restored thanks to improving global economic prospects, the successful foreign currency bond issuances of regional states and the better-than-expected shock absorbing capacity of the banking systems.

Between April 2009 and December 2009, confidence in the region and hence in Hungary has been gradually improving, CDS spreads have been decreasing significantly, and money markets have been stabilising. The greatest challenge for the banking system was the continued balance sheet adjustment and the absorption of credit losses triggered by the deteriorating macroeconomic environment.

2.2.1 Liquidity – during the crisis

In the period following the collapse of Lehman Brothers, practically all investors fled from markets deemed to be risky. Due to international money market turmoil and the high vulnerability stemming from the country's substantial external financing requirement, domestic CDS premia and government security yields increased significantly. Important domestic markets dried up. *(Chart 32)* The operation of interbank, FX-, swap- and government security markets experienced severe disruptions. Besides the financing of the state, that of the banking system was also threatened. The most important liquidity problem was how the Hungarian banking system, characterised by a high FX claims, would secure adequate FX liquidity. Here it wasn't the price that mattered anymore, but rather the volume – this due to the fact that the interbank limits set very low, often at zero, price-offers had no significance.

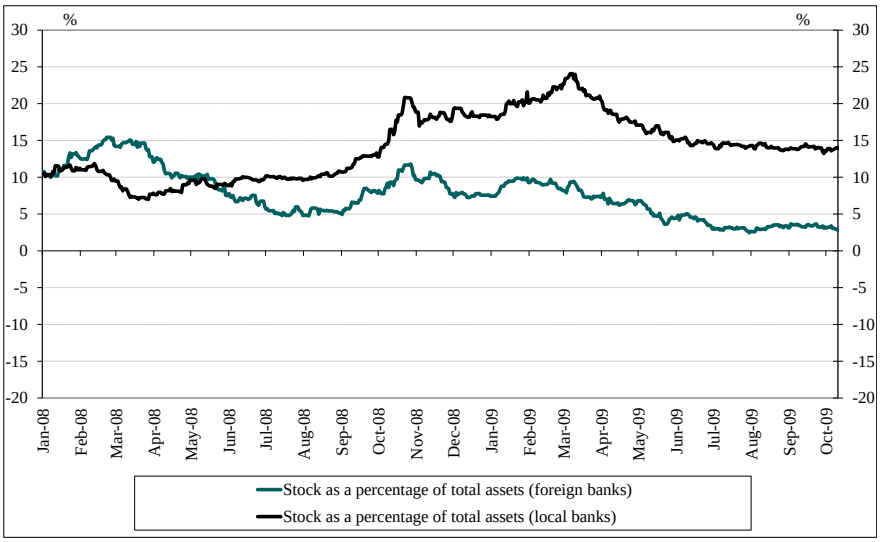
Chart 32 CDS premia on certain foreign banks with a prominent role in Hungary, and Hungary's 5-year CDS premium



Sources: Bloomberg, Reuters, Thomson Datastream.

The international financial package, the liquidity provisioning measures of the central bank and the intervention of foreign parent banks played a key role in solving the problem. Without any parent banks to fall back on, local banks relied more on central bank and state bailout packages. On the one hand, the rolling over of a substantial FX-swap stock became difficult due to the drying up of the market, and in turn due to narrowing partner limits. *(Chart 33)* On the other hand, the rolling over of the increasing FX-swap stock required more and more HUF liquidity, made almost impossible by the dwindling liquidity of the interbank market. Consequently, local banks were only able to obtain the required FX liquidity from the central bank. This was technically achieved by transforming the HUF liquidity provided by the central bank into FX liquidity through FX swaps also provided by the central bank.

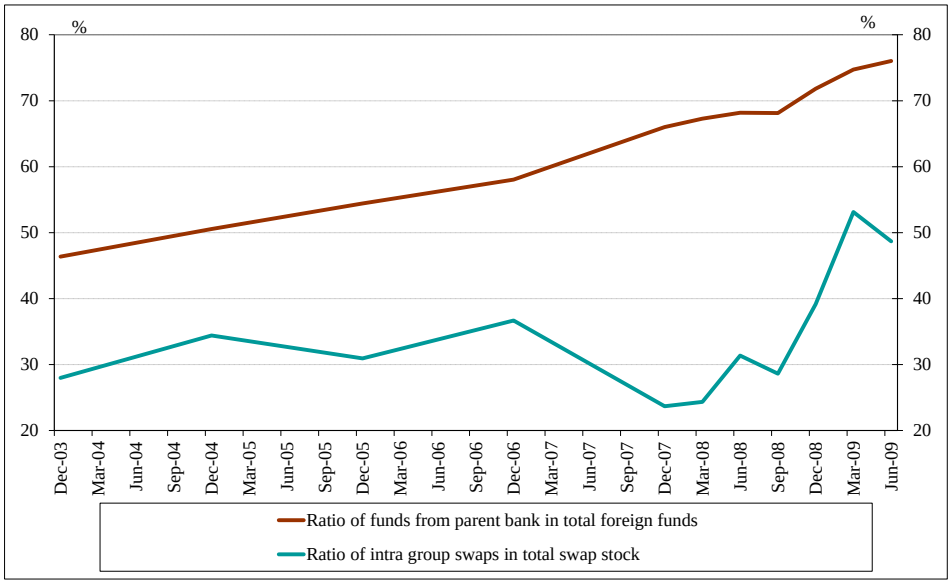
Chart 33 Daily developments in the FX swap stock as a percentage of the balance sheet total



Source: MNB.

The FX liquidity position of foreign banks also deteriorated substantially, although parent banks assumed a key role in managing this problem. *(Chart 34)* As markets for FX liquidity dried up, the subsidiaries of foreign banks operating in Hungary relied more and more frequently on their parent institutions for the necessary funding. In the final quarter of 2008, parent banks increased the funding of their subsidiaries by nearly EUR 3 billion in order to make them more resistant to the liquidity crisis. The role of parent banks also became more dominant on the FX swap market in ensuring FX liquidity.

Chart 34: Development of the ratio of parent banks' fund



Source: MNB.

Rapid, large-scale action by the banks also contributed to the alleviation of the liquidity crisis. As a result of the financial crisis and the economic recession, the real economic sector scaled back its indebtedness consequently the banking system's leverage, more precisely loan-to-deposit ratio also decreased. The liquidity crisis, however, accelerated the scale and speed of deleveraging. Banks themselves recognised that the earlier credit expansion was unsustainable, and thus the era of risk-based competition came to an end. Initially, liquidity considerations – followed by deterioration in portfolios – led to a drastic drop in risk appetite, which was reflected in a low willingness to lend. Decreasing the L/D ratio and that of the reliance on foreign funds and FX swaps became a priority, which curbed the lending appetite of banks, making the operation of the bank system procyclical. Although the number of household loan originations also dropped significantly, it was primarily in corporate lending where the adjustment was most apparent. On the one hand, as corporate loans have shorter terms, adjustment may be first reflected in the loan segment with shorter maturities. On the other hand, corporate loans have lower profit margins than household loans. Finally, compared to retail mortgage loans, corporate loans have a higher risk weighting, and therefore represent a greater burden on capital.

As part of their adjustment strategy, market competition switched over from the asset side to the liability side. From the end of 2008, all major Hungarian banks began aggressive FX

and HUF deposit-taking campaigns. As a result of a fiercer deposit market competition, the banking system increased the propensity to save, but at the same time it drew a large amount of funds away from other forms of saving, primarily investment fund- and cash-type saving instruments. Moreover, the state refinanced maturing HUF government securities primarily from the IMF loan in the first half of 2009. The liquidity thus freed up (investments in HUF government bonds) also flowed into the banking system in the form of deposits. All in all, both the assets and liabilities sides contributed to decreasing the L/D ratio, with the deposit side nevertheless playing a more prominent role.

Regarding the pace and composition of balance sheet adjustment, there are strong differences between the two bank groups. Banks in foreign ownership primarily decreased their activity on the loan side in the area of corporate lending. Competition for retail deposits contributed even to a larger extent to improving the L/D ratio than loan side adjustment. As a consequence of competition, foreign banks increased their share of household deposits, and thus local banks' market share fell further.

The adjustment process of local banks differed from that of their foreign counterparts. Thanks to much lower initial levels, the L/D ratio of local banks decreased less in absolute value, and the structure of the decrease also differed. The lion's share of adjustment for this group was achieved through the inflow of deposits – mainly corporate and other funds (primarily originating from money market funds). In the case of local banks the corporate loan portfolio did not decrease, while the household loan portfolio decreased only to a slight extent.

Parallel to the fall in the loan-to-deposit ratio, the reliance of the Hungarian banking system on foreign funding gradually declined in 2009. In the case of foreign banks, the volume of foreign funds decreased, while the rate of parent bank funds increased. Without parent banks to rely on, local banks replaced renewable foreign funds with state loans.

Adjustment to the liquidity crisis did not only lead to a lower L/D ratio. As the adjustment primarily affected FX-based products both on the loan and deposit side, the on-balance sheet open FX position of banks, and consequently their reliance on the swap market also decreased. The fall in the swap stock was mostly apparent at local banks. By the end of 2009 – in large part thanks to the successful intervention by the central bank – the

Hungarian swap market had stabilised, and so in parallel with the easing of liquidity tensions, interoperability between currencies also improved gradually.

Both foreign and local banks accumulated sufficient liquidity reserves for buffering themselves against possible future shocks. The ratio of liquid assets to the balance sheet total increased over 10 percent by the end of 2008.

From both a macroeconomic and financial stability perspective, it was essential to reduce liquidity and financing risks. The fact that banks adjusted excessively to liquidity risks presented a risk in itself. When liquidity risks materialised, cooperation between the government, the central bank and parent banks restrained an excessively rapid adjustment, thereby making it possible to avoid and mitigate financial acceleration, and preventing the more than justified deepening of the recession.

2.2.2 Solvency in the spotlight

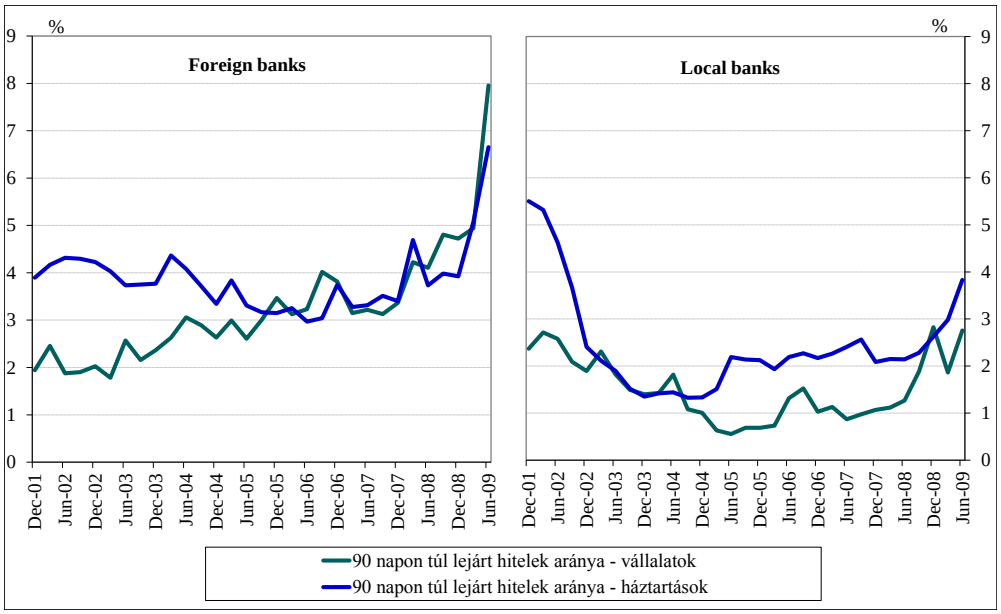
By the beginning of 2009, liquidity tensions in the global financial system seemed to ease, while the adjustment process led to a deep global economic recession. Due to its high trade integration, Hungary 'imported' the recession affecting developed countries, but the rapid, forced adjustment referred to in the previous chapter led to a more severe economic contraction than in other countries, due to the decreased leverage of all economic agents.

In this radically changed financial and macroeconomic environment, many previously creditworthy firms suddenly found themselves cut off from funding, and furthermore, the narrowing of their main outlet markets led to a fall in demand for their products. The corporate loan portfolio thus began deteriorating substantially for both bank groups. The extent of this deterioration in a relative sense was similar for both foreign-owned and local banks, but its level differed greatly. While for local banks, the ratio of corporate loans over 90 days overdue was around 3 per cent, this figure stood at almost 8 per cent at the end of H1 2009 for foreign banks.

The household loan portfolio also began deteriorating rapidly in 2009. The proportion of non-performing or overdue loans first increased in March 2009. Due to increased loan interest rates and substantial depreciation, households – with no natural hedging against exchange rate risks – were less and less able to repay their loans. *(Chart 35)* Following

stabilisation of the financial markets, the portfolio quality was undermined by the labour market adjustment of companies, taking the form of real wage cuts and increasing joblessness. The discrepancy between the portfolio deterioration of the two bank groups is significant. The non-performing loan ratio of local banks was 4 per cent, much lower than the 7 per cent of foreign banks in the middle of 2009. This is only partially explained by the fact that a large portion of the non-performing loans of the local bank group were sold to their own debt collection financial corporations.

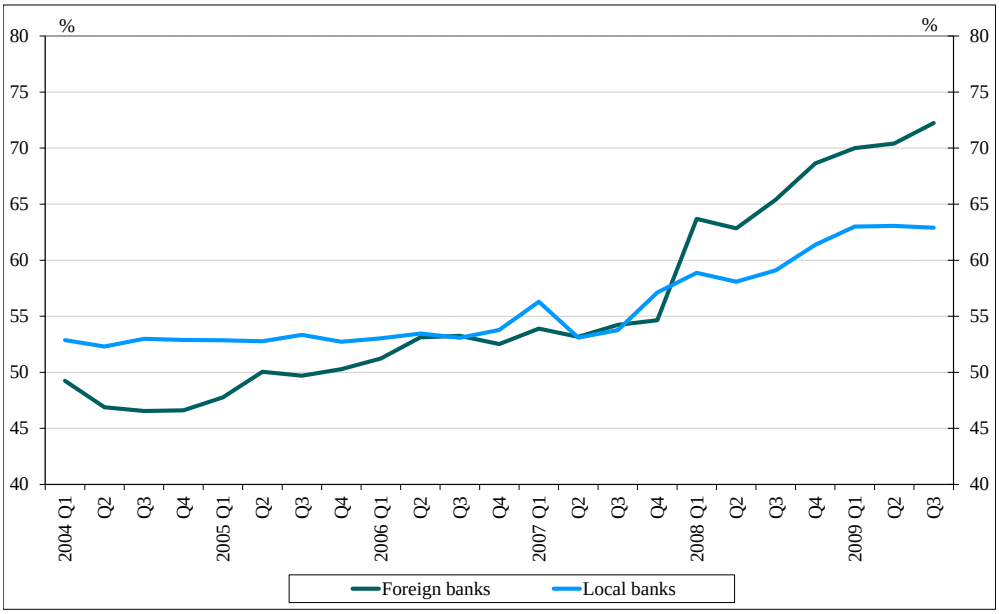
Chart 35: Ratio of loans over 90 days overdue to loan volume among firms and households



Source: MNB.

One of the reasons for the discrepancy is that the LTV of local banks' household loan portfolio is lower: in 2009, the average LTV of local banks was under 65 per cent, while that of foreign banks exceeded 70 per cent. *(Chart 36)* The other factor is that local banks are less active in the home equity mortgage market: while local banks hold one-third of the total market share for household real estate-backed loans, their share is less than 20 per cent in case of home equity mortgage loans.

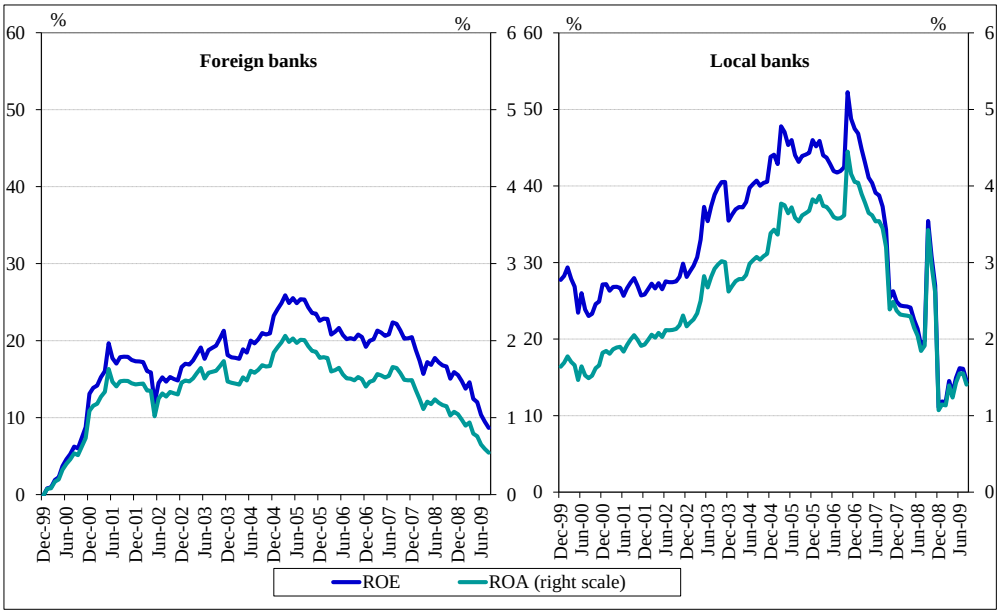
Chart 36: Developments in the average LTV of the housing loan portfolio



Source: MNB.

The crisis deteriorated the banking system's profitability primarily through credit contraction, the narrowing interest margins due to higher financing costs, and loan losses and lost interest revenues stemming from deteriorating loan portfolios. The effects of the crisis already appeared in the profitability for 2008, with the banking system performing worse than previously in the last quarter due to increased provisions. Despite this, both local and foreign-owned financial institutions closed with remarkably good results in an international comparison. Overall, foreign subsidiaries significantly outperformed the banking systems of their parent banks' countries, because while 2008 was a year of breaking even or losses in Western Europe, here banks continued to post a significant profit. In several cases, foreign bank groups owed all of their profit to their subsidiaries in CEE. *(Chart 37)*

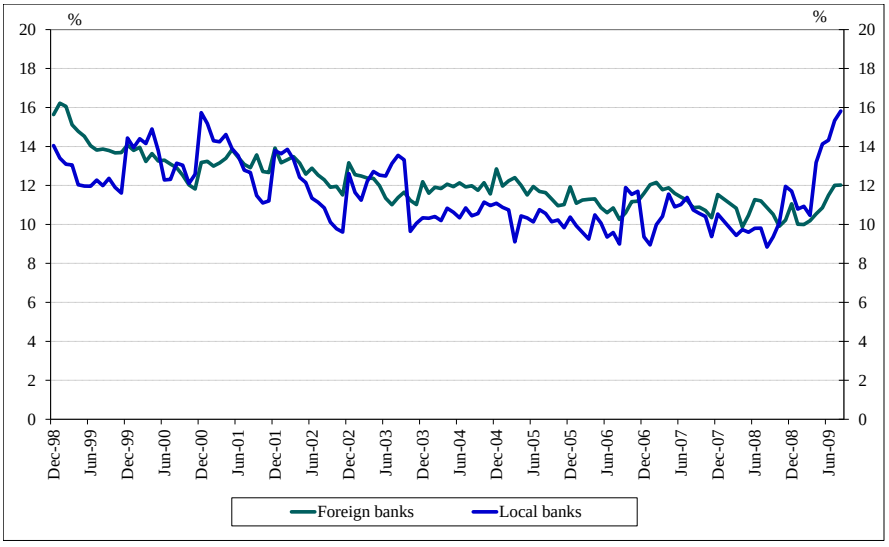
Chart 37: Developments in profitability indicators (12-month rolling)



Note: In case of local banks some jumps are due to one off effects
Source: MNB.

Due to the losses expected as a result of the crisis, the capital position of institutions became a central issue everywhere, including in the Hungarian banking system. Not only was the capital adequacy indicator high overall in the Hungarian banking sector, but the partial reinvestment of 2008 profits and decreased RWA due to forced adjustment led to an improvement in this indicator during the crisis. This improvement was primarily seen for local banks, due mainly to their presence on the stock market and the higher capital adequacy expectations of investors. *(Chart 38)*

Chart 38: Capital adequacy ratio



2.3 Conclusions

Prior to the 2008 crisis, Hungarian banks realised outstandingly high profits. The main source of bank income was rapid credit growth and wide interest margins. In addition to the strong demand for credit from households due to their positive income expectations, fast credit growth was also the result of strong loan supply pressure from banks. Competition between banks intensified, and increasing competition did not result in decreasing prices. Cost-based competition was reflected in higher advertising spending and network building, while risk-based competition was reflected in the sales of increasingly risky products to increasingly risky customers. Interest margins remained high for an extended period precisely because of weak price-based competition.

All of this led to the assumption of ever increasing risks, which came at the price of sustaining high profitability. Rapid credit growth significantly pushed up financing risks, reflected in an elevated loan-to-deposit ratio and a strong reliance on foreign funding and the FX swap market. At the same time, banks' credit risk also increased due to the high level of indebtedness of households and mounting exchange rate exposure. Both foreign and local banks assumed substantial liquidity and credit risk. In comparing foreign and local banks, however, the latter had higher liquidity risks, while the former had higher credit risks.

Following the October 2008 crisis, these risks materialised. Due to the liquidity crisis, banks had to rely on substantial external help, albeit temporarily. In the case of local banks, this was provided by the central banks and the state, while in the case of foreign banks, it was provided by parent banks. Materialisation of financing risks forced all of the banks to adjust to the situation and to restrain their activities. The sharp economic slump – exacerbated by the adjustment of the Hungarian private sector and the banking system – led to the materialisation of credit risks, while lending losses started growing – at a faster pace at foreign banks and a slower pace at local banks. *(Chart 39 and 40)*

The crisis made it clear that the higher the level of risks, the higher the real economic costs of the banking system to adjust to the shock. The 2008 financial crisis hit the Hungarian banking system, which had significant liquidity and credit risks, thus Hungarian banks reacted with strong procyclical behaviour to the changed financial and macroeconomic

environment. All of this, in conjunction with similarly procyclical fiscal and monetary policy, contributed to the Hungarian economy entering a deeper recession in 2009 than the rest of the region. In order to avoid or to alleviate banks' procyclical behaviour, these risks must be reduced and new types of risks must be prevented from developing. The Hungarian banking system should not be allowed to once again become the source of risks which exacerbate the negative effects of an external shock.

Chart 39: Foreign banks' main risk indicators

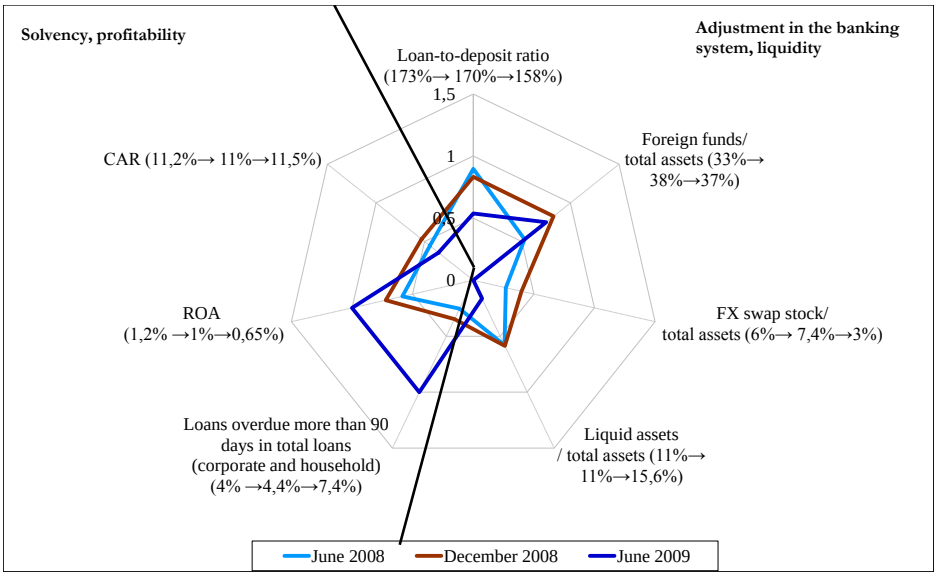
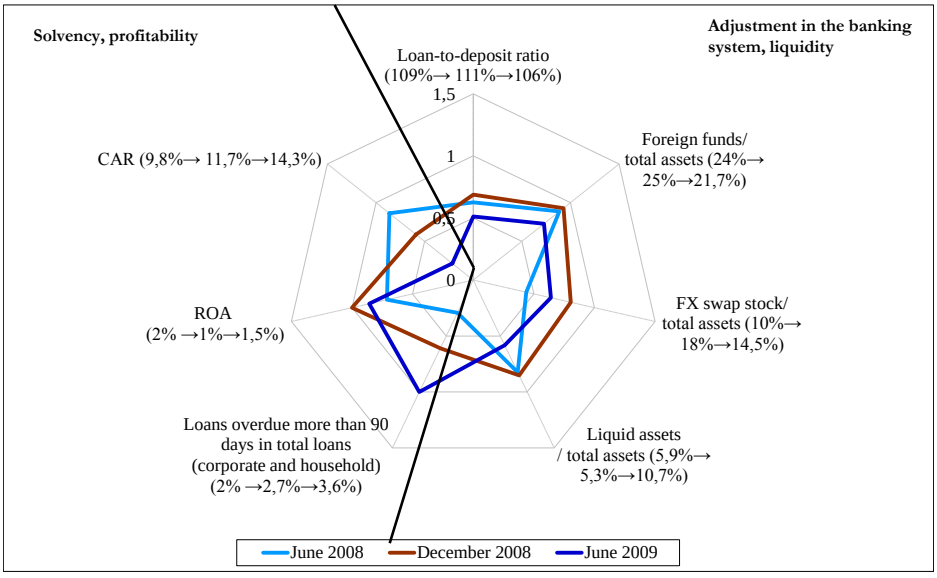


Chart 40: Local banks' main risk indicators



Note: Values falling further from the centre of the web indicate an increase in risks (Chart 39-40)

Source: MNB.

3. TOPOLOGY OF THE FOREIGN CURRENCY/FORINT SWAP MARKET[18]

In our study, we examine the network structure of the currency swap market, the volume of which amounts to several times the Hungarian GDP. With this paper, we aim to establish a complete picture of the market by complementing the results for the overnight market. Additionally, we can now analyse a longer time series than in our 2013 study. We look at the properties of the graphs in segments representing various maturities. We find that the properties of the graph derived from the overall market and the dynamics of those properties are identical to those of the short-term market, while trends differ for various tenors. The longer the maturities, the less the graphs satisfy the small-world property. The longest markets are increasingly closer to random graphs. Although the effect of shocks to large actors is smaller in such graphs, this change also suggests that counterparties trusted each other less as transactions became longer. This is also reinforced by the fact that following the onset of the crisis, the number of connected vertices gradually decreased in the networks of longer markets. In other words, weakening trust is also manifested in the decreasing number of counterparties. This is confirmed by the development of average degree and average path length, and by affinity functions.

JEL: G01, G15, C45.

Keywords: financial networks, FX swap, financial crisis, topology, centrality indices

[18] Banai, Ádám, András Kollarik and András Szabó-Solticzky: Topology of the foreign currency/forint swap market, Financial and Economic Review, vol 14../2. June 2015

3.1 Introduction and precedents in literature

The global economic crisis which erupted in 2007 hit Hungary severely, as the financial markets collapsed following the Lehman bankruptcy. In October 2008, a few weeks after the Lehman default, the key Hungarian money markets also froze up. The government securities market, the unsecured interbank forint market, and the currency swap market all came to a standstill for a few days, which hit the banking system severely as well. Banks are required to continuously renew their currency swaps, in order to close their on-balance sheet open foreign exchange positions off-balance sheet. If they had not been able to renew their expiring swaps, to meet their liabilities they would have been forced to purchase currency on the spot market, which would have placed the forint exchange rate under enormous pressure. In dealing with the problems on the swap market, a major role was played by parent bank commitment, and it was also necessary for the Magyar Nemzeti Bank to introduce new swap instruments.

This episode of the crisis highlighted the key importance of the operation of the FX swap market for financial intermediation in Hungary. Hungarian banks gain access to foreign currency funds partly through FX swaps, which are essential for closing their open positions resulting from their significant portfolios of foreign currency loans. Foreign actors are also particularly active in this market. They enter forward positions through FX swaps, which in many cases they also use to hedge the exchange rate risk of their forint assets. The FX swap market also deserves particular attention from a monetary policy perspective. Disruptions to the operation of this market may significantly reduce forint implied yields, making speculation against the forint cheaper.

The operation and role of the Hungarian currency swap market has been addressed by a number of studies. Páles et al. (2010) provide a highly detailed description of the role played by the market in Hungary's economy. They show how different the motivations of various actors (domestic banks, foreign actors) are for entering the FX swap market. The authors also give an overview of the changes which occurred in the market during the crisis. In the aftermath of the turmoil, in many cases limits for domestic banks were reduced, accompanied by an increased role of margin calls, which further intensified the demand for swaps. Banai et al. (2010) also address the problems experienced in the FX

swap market during the crisis. They find that, prior to the escalation of the crisis in Hungary, it was local banks in particular that had accumulated extremely large stocks of FX swaps. Stock renewal and increasing margining posed a major problem at certain stages of the crisis, which called for the use of the MNB's instruments.

Analyses of the Hungarian FX swap market have mainly focused on the stock size and maturity, the development of implied yields, and the behaviours and strategies of the various actors. However, additional information about financial markets may be obtained through an exploration of the actors' network relationships. Research on the network characteristics of financial markets has gained prominence in the past decade, especially since the onset of the crisis. One of the first studies of this kind was Lublóy (2006), which discussed the network structure of VIBER. According to the study, the network characteristics under review were stable in time. Additionally, the author identified the actors that were the most important for the stability of the network. Surprisingly, these institutions were not the largest banks of the banking system in terms of balance sheet total.

In this paper, we rely heavily on our previous study on the short-term FX swap market (Banai et al., 2013). In our analysis, we demonstrated that the overnight FX swap market also shares the small-world property characteristic of financial networks (for details, see Chapter 3.4 on methodology). Additionally, an examination of the dynamics of network indicators highlighted the significant decrease in the size of the short-term FX swap market after the Lehman bankruptcy. That is, many institutions either cut down on their activity in the market, or left it entirely. However, the exiting institutions were predominantly those with less relevance to the market. This is definitely beneficial in terms of stability. In turn, there is a greater risk from the increased role of the remaining institutions, i.e. the fact that the market has become more sensitive to the behaviour of particular actors.

The tools of network theory are used even more frequently in international literature to examine financial markets. In their research, Iazzetta and Manna (2009) addressed the properties of the Italian interbank market. They explored the behaviour of a number of network characteristics. They found the connectivity of the network to be very low, similarly to real networks, and to be decreasing in time. Another key observation was that the entire network remained connected throughout the 222-month period under review.

That is, with any pair of banks, it was possible to identify a path through which they could reach each other. Their third finding was that, although to a minor extent, the average shortest path increased within the network (for details, see Chapter 3.4 on methodology). They also found that the largest actors were dealing regularly and directly with counterparties playing smaller roles in the network. Finally, the authors demonstrated that the proportion of relatively large actors in the network had decreased, accompanied by an increase in the number of banks dealing only with a few counterparties. In their study, Iori et al. (2008) discussed the Italian overnight market. They demonstrated that banks that were large in terms of degree had a great number of small counterparties. The authors found this to increase the risks of contagion in the case of high-density networks (see details in Chapter 3.4 on methodology).

Soramäki et al. (2006) analysed the network properties of interbank payment data in the Fedwire Funds Service. They found this network also to be sharing the properties characteristic of real networks. Such features include scale-free degree distribution, a high clustering coefficient, and the small-world phenomenon, which was introduced by Watts and Strogatz (1998) and is generally characteristic of financial networks. They also found the properties of the networks under review to be stable in time.

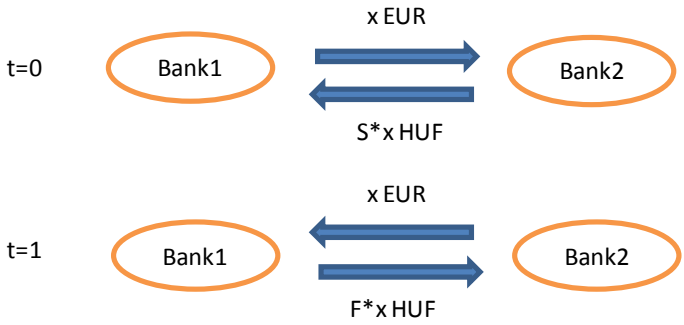
The above list is sufficient to show that in finance, network tools have primarily been used to analyse payment and settlement systems as well as unsecured interbank markets (although Markose et al. (2010) discussed the US CDS market). In neither the Hungarian nor the international literature have we found any papers providing a network analysis of the FX swap market. What follows is our attempt at such an analysis. As we previously discussed the processes of the short-term market in detail (Banai et al., 2013), in this study our primary focus will be on longer markets and their relationship to the short-term market. In Chapter 3.2, we provide a more detailed description of the main characteristics of the Hungarian currency swap market. In Chapter 3.3, we discuss the data used and in Chapter 3.4, we describe the network theory methodology applied. Then, in Chapter 3.5, we present our results on the topology of the network. Finally, in Chapter 3.6, we summarise our findings.

3.2 The currency swap market

3.2.1 The FX swap

A foreign exchange swap (hereinafter: FX swap) is a derivative financial transaction consisting of two legs. On the start (or spot) leg of the transaction, the counterparties swap two different currencies with each other, which they will swap back on the maturing (or forward) leg. When entering into the transaction, they agree on both the spot and the forward exchange rate. FX swaps are also commonly called simple currency swaps, since no transaction takes place between the counterparties other than swapping nominal values, as opposed to currency interest rate swaps (CIRS), where the parties (also) pay interest to each other during the term. With FX swaps against the forint, the market convention is that the same foreign currency amount is traded on the spot and forward legs, and the two forint amounts payable are obtained as the forint value of that amount taken at spot and forward rates *(Chart 41)*. The current exposure to a counterparty resulting from an FX swap transaction as a secured loan (the net present value of the transaction) is an order of magnitude lower than that resulting from an unsecured deposit or loan transaction of the same nominal value.

Chart 41: Starting (t=0) and maturing (t=1) cash flows of a EUR/HUF FX swap transaction with S spot and F forward exchange rates



FX swaps are used for various purposes in financial markets.

1. One widespread trading strategy involves an FX swap plus the purchase of a foreign currency asset (or the repayment of a foreign currency liability). In this case, the actor uses the liquidity acquired on the spot leg of the FX swap to purchase the foreign currency asset to be held (or to repay the foreign currency liability to be

repaid), while the forward leg of the swap provides a hedge against the exchange rate risk of the foreign currency asset (or the foreign currency liability being repaid). Where the asset purchased and the swap mature at different times, the strategy also involves yield speculation. Foreign investors have a propensity to finance their forint government security purchases using FX swaps.

2. Another popular trading strategy is an FX swap and a foreign exchange spot market transaction of the opposite direction. This is equivalent to taking a forward foreign exchange position, since the spot transaction neutralises the spot leg of the swap, leaving only the forward leg effective. An actor may follow this strategy for both speculative (carry trade) and hedging purposes.
3. The third important strategy involves entry into two swaps of opposite directions, with the same spot value dates, but with different maturities. The strategy allows an actor to speculate on interest rate differentials. For instance, if they lend foreign currency in exchange for forints on the spot leg of the long swap, which is swapped back to foreign currency by a bank on the spot leg of a short swap of the opposite direction, then they may refinance the currency repayment upon maturity of the short swap through another short currency raising swap. In this case, profits will be generated for the bank if future short forint yields rise faster in relation to foreign currency yields than what is priced into long yields.
4. Another important role of FX swaps is to revolve maturing forward and FX swap transactions: the foreign currency funds acquired on the spot leg of the swap can be used to repay the foreign currency liability due, while the forward leg can be used to renew the off-balance sheet foreign currency debt.
5. Additionally, this type of transaction can be used solely to grant loans secured by the opposite currency.

3.2.2 The domestic currency swap market

Due to the limited data available, we will only analyse the segment of the domestic currency swap market where at least one of the counterparties to the transaction is a domestic bank. We have nothing more than anecdotal evidence that in London, foreign actors also enter into foreign currency/forint swap transactions (Balogh – Gábriel, 2003).

The FX swap market is a less strictly regulated OTC (over-the-counter) market, where foreign currency/forint transactions are typically traded through brokers in London, which means that direct bilateral contacts and market making are not common (Csávás et al., 2006). At the same time, in the segment of less than one month, by virtue of exclusive access to the MNB's forint market instruments, domestic banks may be considered to be market makers. Table 1 provides a summary of the key properties of the market.

Table 1: Key characteristics of the domestic currency swap* market

Indicator	Value
swap turnover among CHF, EUR and USD relative to HUF/FX swap turnover (2005-Nov. 2014)	44%
daily average turnover of HUF/FX swap market (2005-Nov. 2014, HUF bn)	525
gross HUF/FX swap stock of Hungarian banking system against foreigners (both directions, 1 Dec. 2014, HUF bn)	6006
ratio of interbank transactions to total turnover (2005-Nov. 2014)	95%
ratio of cross-border transactions to total turnover (2005-Nov. 2014)	84%
average transaction size (2005-Nov. 2014, HUF mn)	5474

**Currency swaps are understood in the broad sense, so we have taken into account FX swaps as well as CIRSs for our calculations. By default, we are describing the foreign currency/HUF market.*

Source: Own calculations based on MNB data.

Given the very high ratio of the volume of swaps between cross-currencies and in the foreign currency/forint segment, which points to the possibility of free movement from one foreign currency to another through swaps, the swap markets of various currencies against the forint are treated collectively as a general foreign currency/forint in the rest of this paper, without making a distinction between the USD/HUF and the EUR/HUF segments, for example.

The annual volume of the foreign currency/forint swap market amounted to approximately 5 times the Hungarian GDP in the sample period between 1 January 2005 and 1 December 2014. At the end of the period, the gross foreign currency/forint swap stock of the Hungarian banking system against foreign actors, despite the continuous decrease of the stock of foreign currency loans, amounted to 18% of the balance sheet total of the banking system. These two figures also point to the significant role of the swap market in the domestic economy. Underlying this, in addition to the versatile applications of the

transaction, there are macroeconomic factors as well. Prior to the financial crisis starting on 15 September 2008 with the failure of Lehman Brothers, the country's net external debt and simultaneously the reliance of the banking system on foreign funds had increased significantly. Net external debt equals the sum of the long open forint foreign exchange positions taken by each economic sector (Páles et al., 2010), which means that the open forint position had to be taken by one economic actor or another. Foreign actors were less willing to do so, and therefore, most of the position was undertaken by the domestic private sector through the balance sheet of the banking system, which opened banks' on-balance sheet foreign exchange positions. Pursuant to an earlier government decree and the CRR, however, the banking system had to allocate capital to its entire foreign exchange position,[19] which gave it incentives to close the open position off-balance sheet. Typically, banks close their open on-balance sheet foreign exchange positions through currency swaps, using strategies 2 and 4 above (Páles et al., 2010).

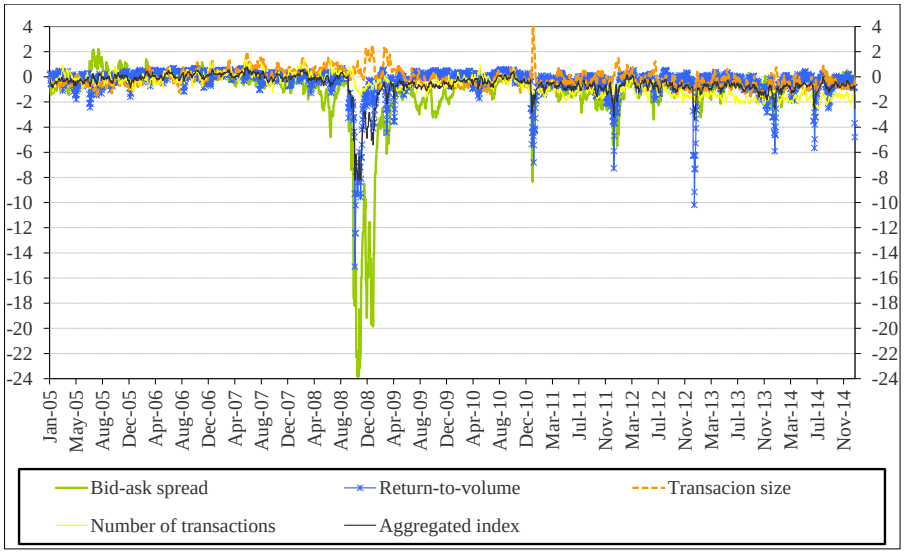
3.2.3 The financial crisis and its effect on the currency swap market

Although the costs of funding in Hungarian markets had been increasing from mid-2007 as the subprime mortgage credit crisis unfolded, and a brief turbulence evolved in the government securities market in March 2008, the global financial crisis essentially escalated in Hungary following the collapse of Lehman Brothers on 15 September 2008. The most intensive phase of the crisis lasted from autumn 2008 to spring 2009. In the autumn of 2008, the cost of liquidity skyrocketed first in foreign currencies and then in forint as market players restricted their partner limits vis-à-vis one another. The turnover of the currency swap market became rather volatile, and the share of intra-group transactions also became unstable. While previously the maturity of swaps had gradually increased, this trend came to a standstill during the crisis, and new swaps became perceivably shorter. Additionally, the euro also replaced the dollar, which had previously played the dominant role in the swap market (Páles et al., 2010).

[19] Where the entire foreign exchange position exceeds 2% of total own funds, the own funds requirement for foreign exchange risk is 8% of the open foreign exchange position.

The overnight market dried up, and the aggregate liquidity index measuring market liquidity fell to -8 by the end of October 2008 (Chart 42). This means that market liquidity was 8 standard deviations below the long-term average of the period preceding the crisis.[20] Meanwhile, swap spreads increased considerably. The spreads of around zero measured before the crisis widened to several hundred basis points. Consequently, in this period forint loans (secured by foreign currency) were available through swaps at rates several percentage points below the reference money market yield.

Chart 42: Liquidity indices of the one-day EUR/HUF and USD/HUF FX swap markets (exponential moving averages)



Note: The liquidity index for the HUF swap market contains data on the one-day USD/HUF and EUR/HUF segments, where the maximum difference between the trade date and maturity is two business days. In every case, the greater value indicates an improvement in the given aspect of liquidity. Specific sub-indices are standardised by their pre-crisis long-term averages and standard deviations.

Source: Own calculations based on data of the MNB, Bloomberg and Reuters.

3.3 Data

We calculated individual network indicators for longer segments (maturities of 3 days to 1 month, 1 to 3 months, and above 3 months), as well as for the graph derived from the overall market. The study will focus on the development of these (Tables 2 and 3). Due to

[20] For more details on the aggregate liquidity index, see *Páles – Varga (2008)*.

its significant volume weight, in our analysis we also consider the 1-2 day segment as defined above. We do so because the above definition is consistent with the segment, the development of which is described by the aggregate liquidity index. However, while the aggregate liquidity index is calculated by the central bank only for the segment comprised of USD/HUF and EUR/HUF transactions, we also considered CHF/HUF transactions.

Table 2: Volume of the foreign currency/forint swap market by currency

	USD	EUR	CHF	together
proportion in turnover (%)	83	15	2	100
proportion in turnover corrected by tenor (%)	38	49	13	100

Note: Based on the forint value of the spot leg of the transactions. In adjustments for maturity, we multiplied the transaction value by the maturity.

Source: Own calculations based on MNB data.

Table 3: Volume of the foreign currency/forint swap market by maturity

	1-2 days	3 days-1 month	1-3 months	>3 months	together
proportion in turnover (%)	76	14	6	4	100
proportion in turnover corrected by tenor (%)	13	8	11	69	100

Note: Based on the forint value of the spot leg of the transactions. In adjustments for maturity, we multiplied the transaction value by the maturity.

Source: Own calculations based on MNB data.

We examined the transactions completed between 1 January 2005 and 1 December 2014. The actors selected to represent the vertices of the graphs included both domestic and international actors, whereas the MNB was excluded. Our analysis concerned only credit institutions, as a result of which we ignored transactions with the non-financial corporate sector, for instance. Domestic banking groups were included in the graphs on a consolidated basis, i.e. members of banking groups were represented by a single vertex standing for the entire banking group. By contrast, we had no means to consolidate all of the foreign banking groups, neither did we intend to cleanse the database from transactions within cross-border banking groups; consequently, we included each member of foreign or cross-border banking groups separately in the database. The edges between the vertices were derived from the transactions between them (and not from existing stocks). For 1-2 day transactions and the entire network, we created the matrices to describe the graphs by aggregating transactions at intervals of 5 business days. Additionally, for the sake of comparability we also created the graphs at a monthly frequency. This was needed because with segments longer than 1-2 days, we only examined monthly graphs. The main reason

for that was that the number of transactions is far lower in such segments, and the size of the networks obtained through 5-day aggregation proved to be too small. We examined transactions longer than overnight in three groups: 3 days to 1 month, 1 month to 3 months, and transactions exceeding 3 months. We established each group by taking two important aspects into account. On the one hand, we needed a sufficient number of vertices for our analysis, while we also needed to consider, to some extent, the different roles of the transactions with different maturities. We added up the signed forint values of the spot legs of the swaps among the individual actors, assigning a positive value to a transaction where the bank received currency on the spot leg, and a negative one in the opposite case.

3.4 Methodology

In this chapter, we briefly explain the network theory tools that we used in our analyses (the methodology is identical to that used in our previous paper (Banai et al., 2013)). Our aim is to provide a straightforward definition of the indicators characteristic of the network, occasionally at the expense of mathematical precision. Specific results concerning the FX market will be discussed in the next chapter.

3.4.1 Adjacency matrices and components

Let us assume N banks to be given, and W to be an NxN matrix wherein element $W_{i,j}$ indicates the forint amount given by bank i to bank j on the spot leg. In fact, W is a matrix including ***bilateral exposures*** in forint. Each element of the matrix W is non-negative and it is not necessarily symmetric, and we assume every element along its main diagonal to be zero. The matrix thus obtained defines a weighted and directed graph without loops,[21] where the weight of each edge determines the size of the claim, and the direction determines the direction of the cash flow. Note that where banks i and j have mutual claims on each other, we use a netted claim obtained as a signed sum of the claims. In analysing the network, the question is often simply whether two actors are connected or not, the size and direction of their connection is less important. This is because the formation of a connection in itself may provide relevant information, while facilitating the understanding

[21] Loop: an edge starting from and ending in the same vertex.

and interpretation of the indicators. Additionally, it is important to consider the fact that FX swaps are secured transactions. Consequently, direction is less significant than with commonly analysed unsecured markets.

Let *A* be an adjacency matrix representing an undirected and unweighted network, i.e.

$$A_{i,j} = \begin{cases} 1, & W_{i,j} + W_{j,i} > 0 \\ 0, & otherwise \end{cases} \quad (1)$$

The inequality $W_{i,j} + W_{j,i} > 0$ in the above definition will be satisfied exactly when an edge leads from *i* to *j* or from *j* to *i*, i.e. matrix *A* truly represents an undirected network. For example, with the 1-2 day market, the matrices were created by aggregation at intervals of 5 business days, i.e. by obtaining a signed sum of the daily transactions. For aggregation purposes, we did not consider bank holidays in the USA, Switzerland and Europe to be business days because the volume of trade is significantly lower on such days. In calculating the network indicators discussed below, we generally require the network to be connected in some sense.

3.4.2 Network indicators

Network size

One of the most general characteristics of the network is its size, which indicates the number of banks participating in at least one transaction in a given period either as borrowers or lenders.

Degree

In a directed graph, the indegree (outdegree) of a vertex *i* is understood as the number of edges leading to (from) that vertex.

With undirected networks, the degree of *i* is the number of vertices connected to it. More precisely, if the degree of vertex *i* is indicated by *f(i)*, then

$$f(i) = \sum_{j=1}^{N} A_{i,j} \quad (2)$$

Degree is commonly included among centrality indicators, i.e. characteristic quantities which are supposed to describe the importance of the role that a given vertex plays in the network.

Another key quantity is degree distribution. This function indicates the frequency of a given degree value. In networks occurring in reality, degree distribution often follows power law. More precisely, if the frequency of degree *k* is indicated by *p(k)*, then

$$p(k) = ck^{-\gamma} \qquad (3)$$

where *c* is a normalising constant and γ is a positive number, mostly in the interval of [2,3]. Such graphs are called scale-free networks (Barabási – Albert, 1999). Networks occurring in reality mostly include a large number of low-degree vertices and few higher-degree vertices.

Average path length, diameter and mass function

The distance between vertices *u* and *v* is understood as the sum of the weights of the edges along the shortest path between them. In our analyses, we will always consider the largest connected component where we want to use the shortest distance or some of its functions. In the rest of this paper, let *d(u,v)* indicate distance. In an unweighted graph, *d(u,v)* will indicate the minimum number of steps required to be taken to get from *u* to *v*. Average path length is defined as the average of such distances, and the diameter of the network as the maximum of such distances.

We also introduce a measure called mass function, which indicates the proportion, relative to all shortest paths, of the shortest distances that will be less than or equal to a given constant *k* (*k*=2, 3, 4, 5). Obviously, the function increases in the *k* parameter, and where *k* equals the diameter of the network, the result will be 1, since every shortest path is either less than or equal to the diameter.

Closeness[22]

The closeness of a vertex *u* is the inverse of the length of the path to vertex *v*, which is at the greatest distance from it. More precisely, if closeness is indicated by c(u), then

$$c(u) = \frac{1}{\max_v d(u,v)} \qquad (4)$$

[22] We also calculated another version of the average closeness indicator. In that indicator, we inverted the average of the shortest paths rather than their maximum. However, we obtained similar results in both cases.

The $\max_v d(u,v)$ quantity itself illustrates the number of steps required to get from u to any vertex. Inversion is necessary because we want the closeness of a vertex to be the higher the more central the vertex is to the network, i.e. the fewer steps are required to get to any vertex from it. It is for this property that closeness is considered to be a centrality indicator as well.

Betweenness

Betweenness indicates the number of shortest paths that include a given vertex. We do not count the shortest paths starting from or ending in the vertex concerned. In order to compare betweenness indicators across networks of different sizes, we need to divide the indicator by the maximum number of shortest paths, which for *N* vertices will give

$$\frac{(N-1)(N-2)}{2} \quad (5)$$

The above formula will determine the maximum number of shortest paths that may include a given vertex without starting or ending in that vertex.

Density

Density indicates the ratio of the number of edges to the number of all possible edges. The number of all possible edges in an undirected network of *N* vertices is

$$\frac{N(N-1)}{2} \quad (6)$$

as every vertex may be connected to a maximum of *N-1* vertices, but that would include all edges twice. Note that in the case of a directed network, the above formula is modified to $N(N-1)$.

Clustering coefficient

The clustering coefficient of a given vertex shows the ratio of the number of edges between its neighbours to the possible number of edges between its neighbours. In other words, the average clustering coefficient determines the probability of the neighbours of any vertex being connected with one another as well.

Affinity function

The affinity function indicates the average degree of the vertices connected to vertices of a given degree. That is, the function assigns a number to every degree occurring in the network. If the function increases monotonically, vertices of a higher degree will also be connected to vertices of a higher degree, i.e. the key actors will be directly connected to one another. Otherwise vertices of a higher degree will only be connected to vertices of a lower degree, i.e. larger actors will only deal directly with smaller banks.

The small world property

In networks exhibiting the small world property, the average shortest path between vertices is low relative to the size of the network. Additionally, the average shortest path is proportional to the logarithm of network size, i.e.

$$Average\ shortest\ path = c\ log(N)$$

where *c* is constant.

3.4.3 Random graphs

One of the longest established and most studied random network models is the so-called Erdős–Rényi graph (Erdős – Rényi, 1959). The scheme involves a fixed *N* number of vertices, where two different vertices will be connected with a probability of *p* and will not be connected through an edge with a probability of *1-p*. Primarily, we would like to use the Erdős–Rényi network to compare its average clustering coefficient with that of the graph obtained by us. If the two indicators are close, i.e. their ratio ≈1, we may conclude that our network has no meaningful structure. The question arises how we should construct an appropriate Erdős–Rényi model for a given graph. Obviously, the number of vertices must be identical, and the value of *p* should be selected as follows:

$$p = \frac{\text{average degree}}{N-1}. \qquad (7)$$

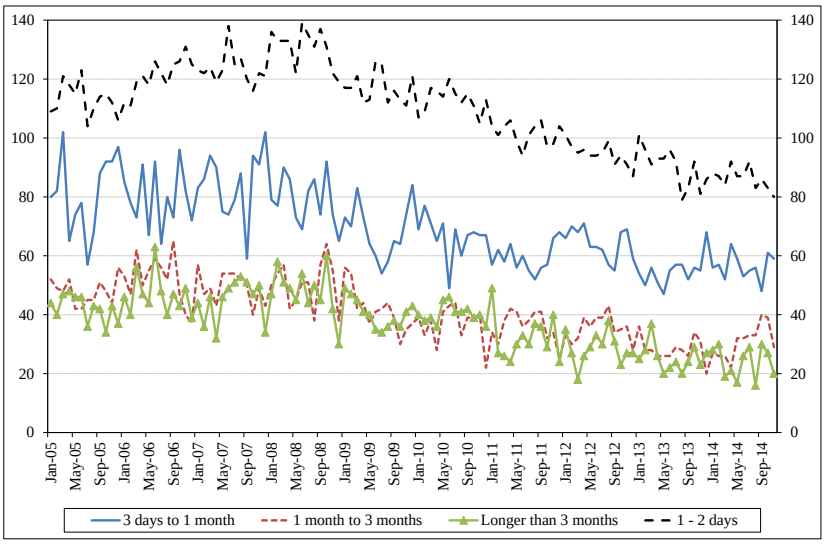
Since our database only includes transactions reported by Hungarian actors, we will slightly adjust the above model because in our network the probability of an edge between two foreign counterparties is zero. Let us consider the sub-graph that only includes domestic

actors and the edges between them. Let G_{DD} indicate the Erdős–Rényi graph belonging to this network. Additionally, let us create another Erdős–Rényi model for a bipartite graph representing domestic–foreign relationships. A bipartite graph includes two disjoint sets of vertices (domestic and foreign actors), where the edges may only connect domestic and foreign vertices, but neither two domestic nor two foreign vertices. The random graph scheme is modified in that we will only try to connect *i* and *j* vertices with a probability of *p* where *i* is a domestic actor and *j* is a foreign actor. Finally, let us unite the network so obtained and graph G_{DD}. In the rest of this paper, we will refer to the graph created this way as a modified Erdős–Rényi network.

3.5 Results

In the analysis of the overnight market, several findings raised the possibility that the dynamics observed may be caused by the increased prominence of using longer markets (Banai et al., 2013). Further analyses suggested that probably this was not the case, but in the following we explore the specific features of the overall market in detail. In the previous chapter, we described the mathematical tools that we used to map the network structure of the currency swap market. The set of indicators enable us to gain an understanding of the key properties of our network and their development over time. In our calculations, we also examined each indicator separately for segments of various maturities. Additionally, our results include the development of network statistics that ignore maturities and thus describe the overall market.

Chart 43: Number of vertices in the networks of segments of various maturities (monthly frequency)

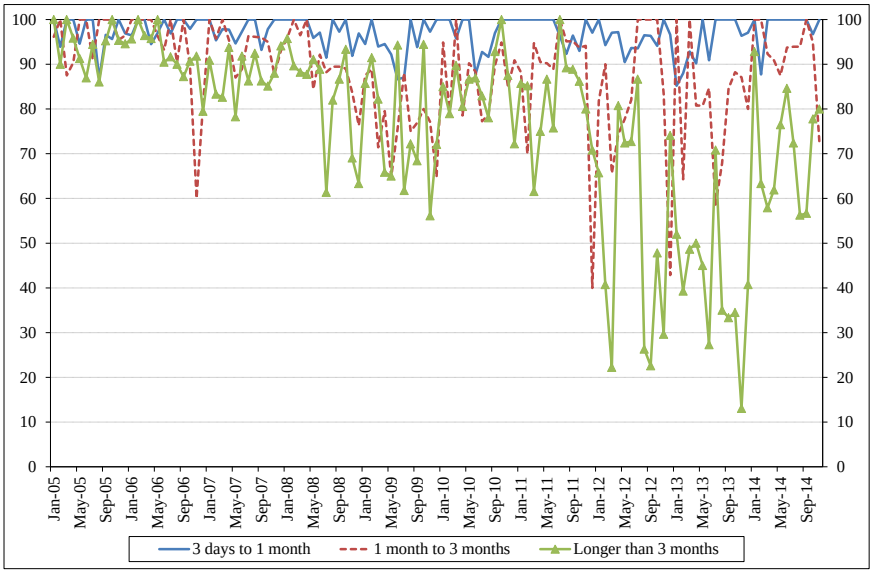


Source: Own calculations based on MNB data.

Our analysis of short markets showed that network size, i.e. the number of banks trading in the given period, is far from being constant (Chart 43). For a while, size was perceivably growing as foreign currency lending took off. From summer 2007 onwards, a series of crisis events could be read from size dynamics. The bankruptcy of Northern Rock caused a break, the so-called decoupling period brought growth, and then the Lehman failure led to a fall. From the second half of 2010, another downward trend emerged, which continued to the end of the period observed. In the networks of segments of longer maturities, the number of vertices fell significantly short of the 1-2 day segment, despite the longer frequency. At the beginning of the period, size exceeded 100 in the 1-2 day network and was still at 70 at the end of the period at a weekly frequency. At a monthly frequency we obtained even higher values, with a maximum at 140 and a size approximating 100 even at the end of the period. This is consistent with the need for actors to renew shorter transactions significantly more frequently. It is seen that in autumn 2008, the number of vertices suddenly dropped in all three long segments. Late 2009 and early 2010 marked the beginning of a more spectacular downward trend. That is, in periods when the size of the short market contracted, a similar trend emerged in longer markets as well. This disproves the possibility that the increased prominence of transactions with longer maturity may have caused the size of the short market to contract. At the same time, it supports the position

that many actors were forced to exit the foreign currency/forint FX swap market by an increase in risks, despite credit risk remaining low. It is worth noting that the transactions entered into with the MNB in accordance with the forint conversion announced in November 2014 did not result in any significant changes in the number of actors in November. Only the 1 to 3-month market showed some increase. This may be due to the fact that counterparties will receive currency from the MNB, which they can use to close their market swaps among other things, with a delay, between 2015 and 2017. Consequently, the size of the market is expected to contract only later.

Chart 44: Ratio of the vertices in the largest weakly connected component to the size of the entire network in longer markets



Source: Own calculations based on MNB data.

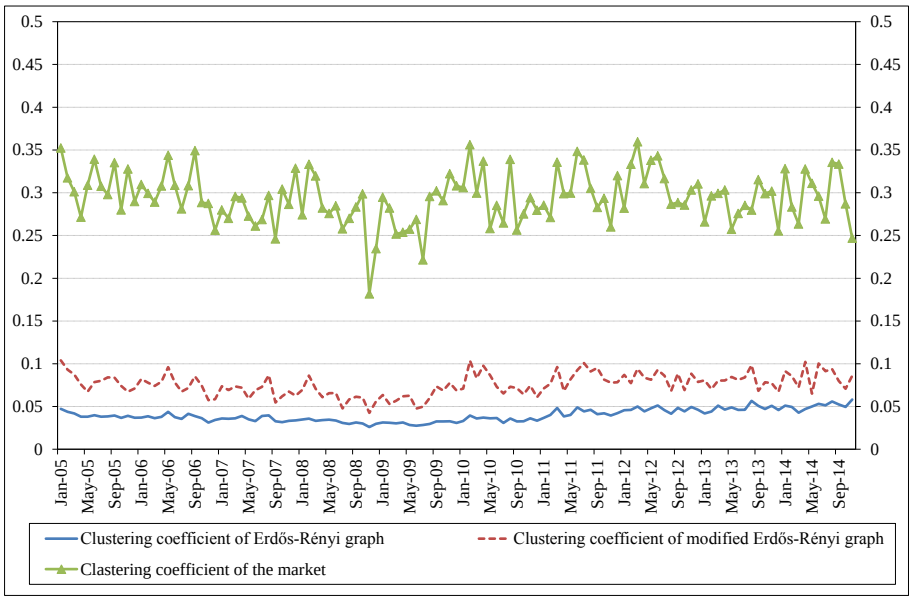
In terms of our research, the first and most striking network property of the FX swap market is that the graph obtained is often not connected. When we consider the network formed on a single trade day, the network is found to be disintegrating into several (in some cases more than 10) separate parts. For our analysis, it is important to obtain a connected network, since the calculation of certain centrality indicators only makes sense if we do. It was an important question in the case of the 1-2 day market as well to find the sufficiently short frequency where a connected network is formed. Due to the small size, this problem becomes even more significant with longer segments. We decided to use a monthly frequency in such cases. A lower frequency would already "conceal" many events, and as

such would not be a suitable choice. However, it is apparent that, especially with transactions exceeding 3 months, in extreme cases the largest connected component is comprised of only 20 to 30 percent of the actors. That is why a higher frequency is not recommended either (Chart 44).

A key question is what causes this disintegration. In the literature, we have found several references to examples of markets which were not completely connected as networks (e.g. Berlinger et al., 2011, Bech – Atalay, 2008). Such a level of disintegration may be explained by the fact that a major part of the actors are foreign banks. In many cases, foreign actors mostly trade with their own local subsidiary banks. When the relationship is mutually exclusive, the two vertices will break away from the rest of the network. A further obvious explanation may be the fact that we are unable to see a part of the network (transactions between foreign actors). Naturally, at progressively higher frequencies, the decrease in the number of transactions in itself increases the probability of separate bank pairs, triangles, etc. being formed. It is important to note that from the beginning of the crisis and particularly from autumn 2008 onwards, the absence of connectivity became increasingly prominent. With the exception of the 1-2 days market, the ratio of the largest connected components to the entire network gradually diminished in every segment. This points to increasing mutual distrust, which motivated participants to enter into longer transactions only with a small group of counterparties. Transactions of longer maturities also involve increased risk, which is why it is reasonable to select counterparties even more rigorously in longer markets.

Although it is possible to calculate some of the indicators even with the network disintegrating, the calculation of most centrality indicators requires at least weak connectivity. For that reason, we will consider the largest connected component throughout the rest of our investigation. As seen above, in some exceptional cases, the greater part of the network falls outside of the greatest connected component. Consequently, with the longest markets the conclusions that can be drawn from the network indicators are limited. In the rest of this paper, such conclusions will primarily be used to support the conclusions drawn in the short market.

Chart 45: Average clustering coefficient of the entire swap market graph and the random Erdős–Rényi graphs of equivalent average degree

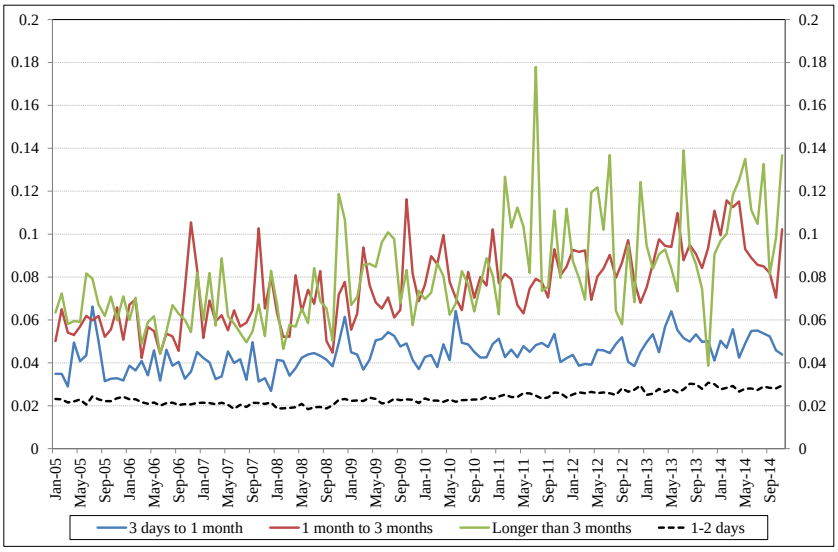


Source: Own calculations based on MNB data.

We examined the extent to which the graph can be considered random. For this purpose, we compared the graph of the swap market to random graphs generated using two methods. On the one hand, we compared it to a random Erdős–Rényi graph, the average degree of which was identical to that of the swap market graph. On the other hand, we also considered a modified random Erdős–Rényi graph, where we assigned varying probabilities to the edges between domestic–domestic, domestic–foreign and foreign–foreign vertex pairs. In the modified random graph, a connection is established between two foreign vertices with a probability of 0.

We calculated the average clustering coefficient for all four graphs. We found that the level of clustering in the swap market graph significantly exceeded the level of clustering in both random graphs for all maturity segments (overall market: *Chart 45*, short market: 3 times larger clustering on average; 3 days to 1 month: 3 times larger clustering; 1 month to 3 months: 2 times; above 3 months: 2 times). Consequently, the swap market network cannot be considered to be random (although the clustering coefficient approximates that of the random graph as maturity increases), and as such it is worth examining in more detail.

Chart 46: Ratio of average path length to size in individual segments

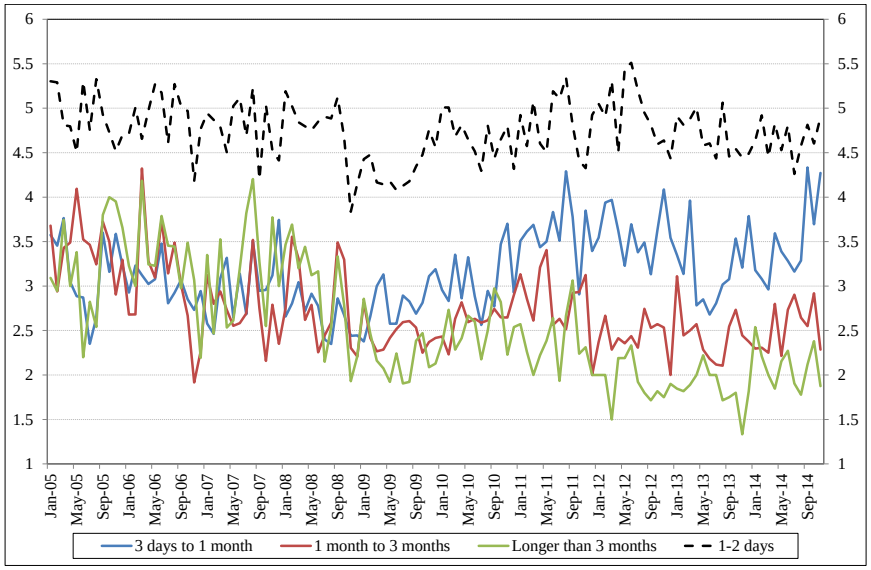


Source: Own calculations based on MNB data.

Banai et al. (2013) have demonstrated that the network of the 1-2 day market may be referred to as a scale-free network. Accordingly, the degree of individual vertices approximately follows power law. If *k* denotes individual degrees, then the power function $53*k^{-2}$ will give a fairly good approximation of degree frequency. As a result of the distribution following a power function, the graph includes many low-degree and few high-degree vertices. The small world property may also be captured through the development of specific network indicators. One of them is the ratio of average shortest path length to network size. A low ratio will indicate the small world property. The small world property is also indicated by a clustering coefficient exceeding that of the random graph, or an average shortest path length proportional to the logarithm of network size (Pető–Békési, 2009; Newman, 2003). Clearly, the first indicator shows significant differences with segments of various maturities (Chart 46). In the case of the 1-2 day market, the average shortest path length amounts to a mere 3% of the network size in general. However, the indicator significantly increases with longer maturities (3 days to 1 month: 4.5% on average; 1 month to 3 months: 7.5%, above 3 months: 8%), showing an approximation to so-called lattices (Pető–Békési, 2009). This is confirmed by the ratio of the average shortest path length to the logarithm of network size. The longer the segment being considered, the less constant the indicator became. Overall, it appears that the longer the maturities, the less

the network can be considered to satisfy the small world property. In networks, the small world property poses a stability risk. Namely, such networks respond drastically to shocks affecting the largest actors, although shocks to small actors have no significant effect (Albert et al., 1999; Newman, 2003). In times of crisis, central actors tend to amplify and accelerate contagion (Markose et al. 2010). Conversely, with random graphs shocks to the largest actors have a smaller effect. The longer the markets, the smaller the chance of contagion. This also follows from the gradually decreasing ratio of elements that are part of the largest component. An analysis of the entire swap market as a single network shows that the two indicators behave similarly to the 1-2 day segment, i.e. the small world property is also satisfied in this respect. This is explained by the fact that within the overall market, 76% of all transactions were made in the overnight segment.

Chart 47: Average degree in various segments

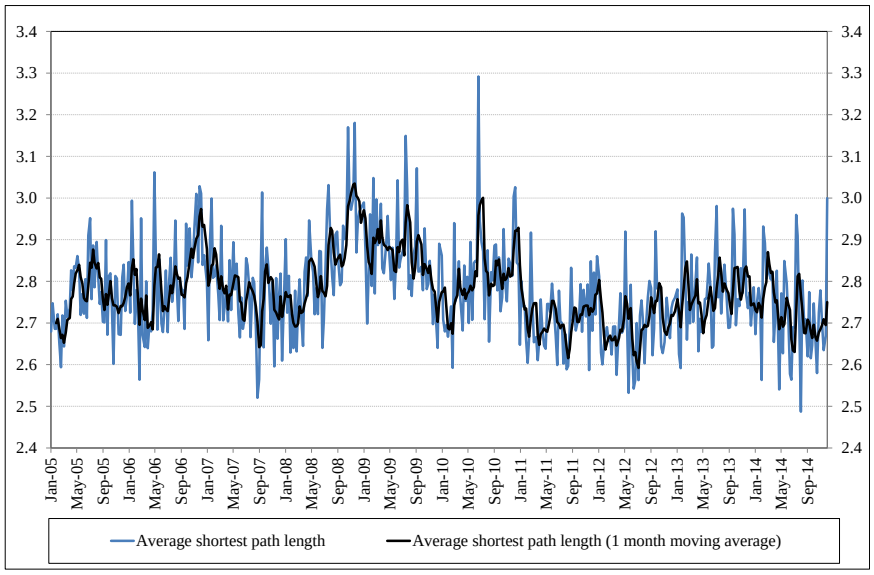


Source: Own calculations based on MNB data.

Throughout the period under review, the average degree of the network varied significantly across segments in terms of both trends and levels (Chart 47). In the shortest market at a weekly frequency, a change in the indicator could be observed at both turning points of the financial crisis, i.e. in summer 2007 and autumn 2008 as well. In mid-2007, for a brief period there was a significant decrease in the average degree of the network, and then the indicator moved at previous levels right up to the Lehman bankruptcy. In turn, after the Lehman bankruptcy, the indicator remained below previous levels for an extended period,

which was followed by a continuous increase from autumn 2010 (Banai et al., 2013). At a frequency of one month, the change in the 1-2 day segment was also striking at the time of the Lehman bankruptcy and from the second half of 2010. However, the picture is different with the rest of the segments. On the one hand, as we expected, the level of average degree is significantly lower due to differences in size. On the other hand, we also found differences in trends. While the segment of 3 days to 1 month behaved similarly to the shortest market, the graphs derived from transactions exceeding 1 month moved in the opposite direction. With the former, the average degree reached its peak by the end of the period, which means that the weight of relatively important banks increased across the network. With the latter, however, the average degree decreased. This may also indicate banks' increased tendency in the aftermath of the crisis to select the counterparties with which to enter into longer transactions.

Chart 48: Average shortest path for the entire swap market

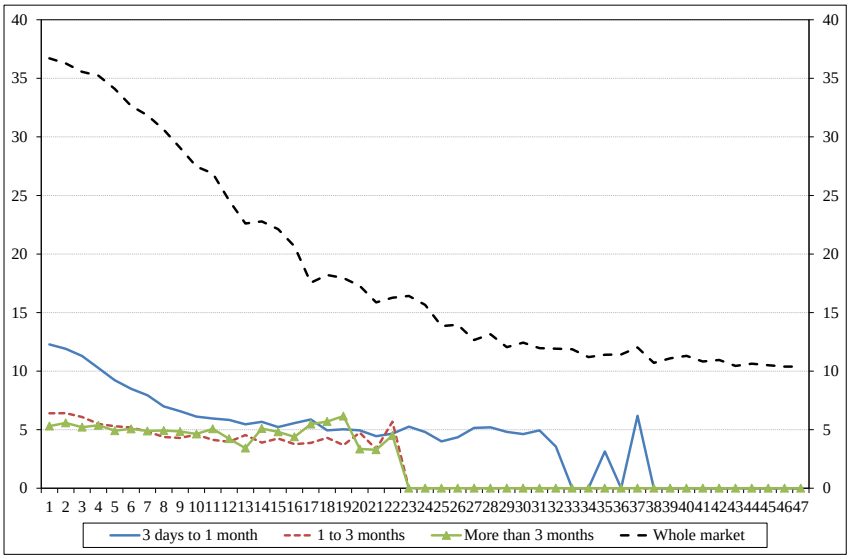


Source: Own calculations based on MNB data.

Not surprisingly, average shortest path length moved in the opposite direction to average degree. This was also observed for the 1-2 day market (Banai et al., 2013), but also applied to the graph including all of the transactions regardless of maturity. Due to the fact that individual actors enter into transactions with an increasing number of counterparties, new edges allow the formation of additional and shorter paths between two vertices. Obviously, the opposite is also true. Fewer counterparties mean fewer variations of possible paths,

causing the average shortest path to increase (Chart 48). With segments longer than 2 days, average shortest path length was around 3 in the period under review. The obvious trends and turning-points seen in the overall market were increasingly less prominent there. It was apparent particularly in the longest segment that although the indicator was highly volatile, no trends could be established in its movements.

Chart 49: Affinity functions of longer segments and the overall graph



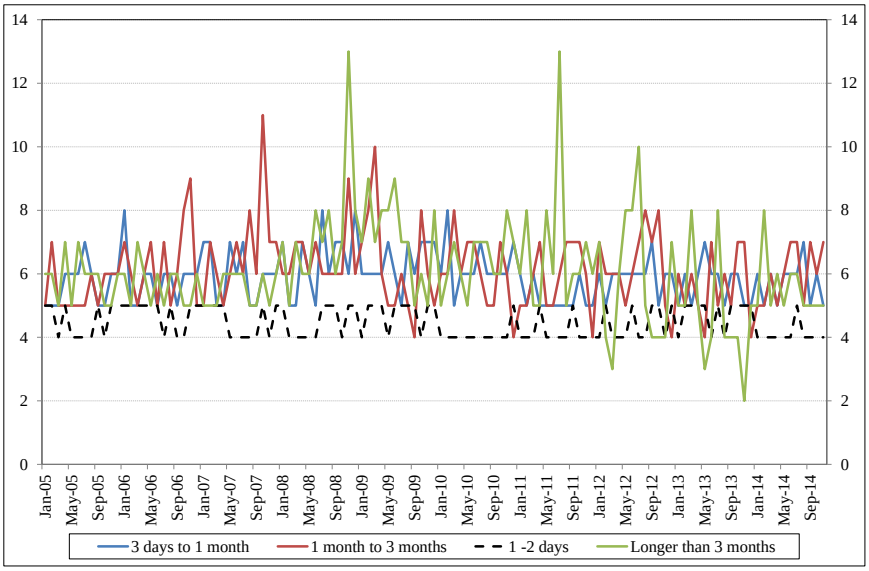
Note: Axis x shows the degrees of individual vertices, whereas axis y shows the average degrees of neighbouring vertices. For example: in the overall market the vertices neighbouring vertices with a degree of 1 had an average degree of around 37.

Source: Own calculations based on MNB data.

An important question relating to the development of degrees is the degree which the neighbours of vertices with various degrees have themselves (Chart 49). In financial networks, banks with a high degree typically deal with counterparties that have a low degree (the phenomenon has been described in Iori et al., 2008, and Iazzetta et al., 2009). This was so in the case of the Hungarian 1-2 day FX swap market (Banai et al., 2013), and is observed in the graph derived from the overall market (Chart 49). One reason for this is the high number of small actors in the network, which drives the most active actor to also become connected to actors with few counterparties. On the other hand, account should be taken of the fact that the actors considered small in terms of the domestic currency swap market include many banks that are prominent internationally as well. This disassortativity is also characteristic of longer markets (Newman, 2003), but to a smaller extent. The

downward sloping affinity function is still clearly visible in the segment shorter than 1 month; however, in longer segments counterparties have much more homogeneous average degrees. This may indicate that a central role is played by a few actors to a smaller extent.

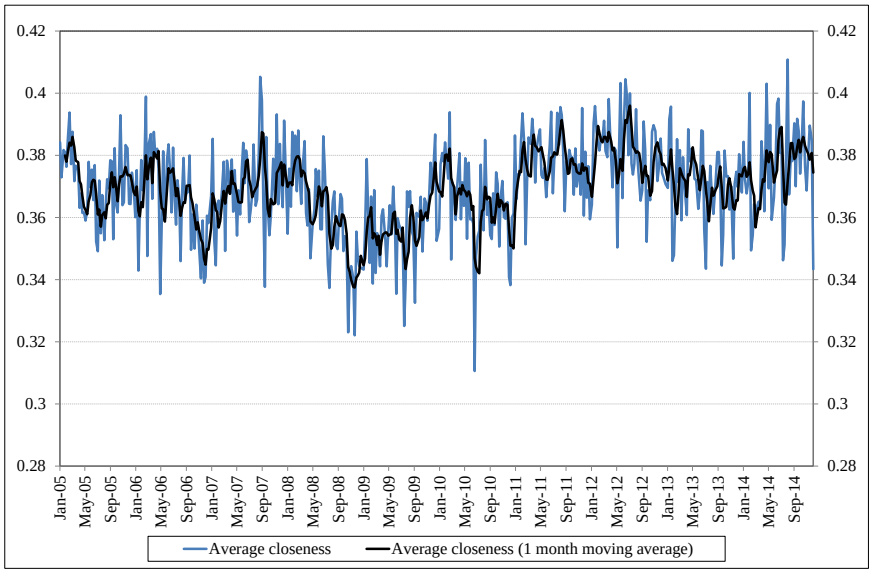
Chart 50: Diameter in specific segments



Source: Own calculations based on MNB data.

The size of network diameter may be dominant in the spread of shocks. As a rule of thumb, in social networks the small world property means a maximum diameter of 6 (Newman, 2003). In the 1-2 day FX swap market, diameter was found to be rather stable in time. Throughout the period under review, average diameter was 5.2 at a weekly frequency and 4.4 at a monthly frequency. Moreover, at a monthly frequency the lowest value was 4 and the highest was 5, i.e. the indicator hardly changed over time. In longer segments, diameters averaged around 6 and increased as maturities became longer (3 days to 1 month: 5.9 on average, 1 month to 3 months: 6.1, above 3 months: 6.1). Apart from this, longer maturities also involved higher volatility. In such turbulent times as autumn 2008, the diameter of certain graphs exceeded 10 (Chart 50). In other words, fewer and fewer connections were formed between banks. While this obviously reduces the risk of contagion, it also means that certain banks would not be able to enter into transactions with a sufficient number of counterparties. As a result, they may have been forced to rely excessively on a single counterparty in longer markets.

Chart 51: Average closeness in the overall market

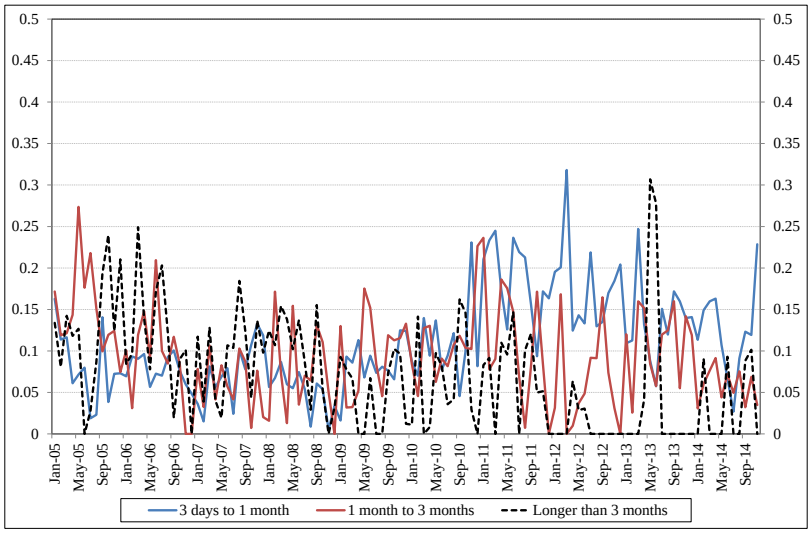


Source: Own calculations based on MNB data.

In the case of the unsecured forint interbank market, the indicator of average closeness was the quickest to respond to the crisis. Although from a rather high level of 0.5, it started to decline as early as in 2006, and already moved around 0.4 in early 2009 (Berlinger et al., 2011). All of the networks in our analysis deviated from this in terms of both trends and levels. In the graph of the overall market, the network indicator perceivably changes as problems develop. We could see an increase from late 2006 to spring 2008, followed by a decrease, which was intensified by the Lehman bankruptcy. Therefore, in this case the trend changed earlier than in the 1-2 day market. The sharp decline around the Lehman bankruptcy coincided with that seen in the 1-2 day market, just as the continuous increase from 2010. The two graphs differ primarily in terms of levels. In the network of the overall market, the highest average exceeds 0.4, which is significantly higher than the maximum of around 0.3 measured for the 1-2 day segment (Chart 51).

In longer segments, a decrease in average closeness was also felt in autumn 2008 (3 days to 1 month: 0.29 on average, 1 month to 3 months: 0.2, above 3 months: 0.2). On aggregate, however, the time series appeared stable without any significant changes. This suggests that the periphery of the network exited the market mostly in shorter segments (Banai et al., 2013). In the rest of the segments, it is not clear how important exiting actors had been for the network concerned.

Chart 52: Average clustering coefficients in longer segments



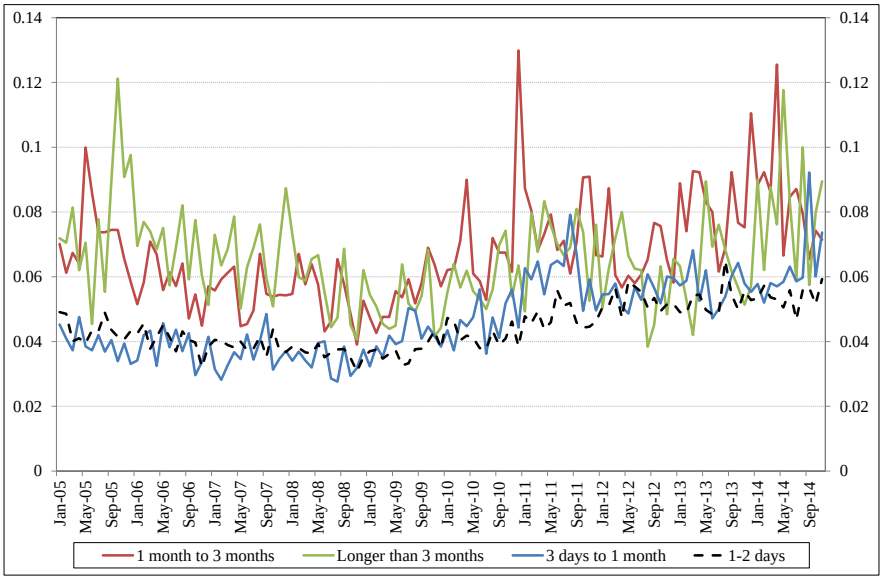
Source: Own calculations based on MNB data.

The clustering coefficient is a key indicator in terms of stability both at systemic and individual levels. Its movements aptly describe the extent to which cliques are formed in the given market, and how typical it is for the partners of specific banks to enter into transactions with one another. In the period under review, major crisis events led to significant drops in the indicator. For most of the period, the indicator moved between 0.1 and 0.2 in the 1-2 day market, hitting a low of 0.05 at the time of the Lehman bankruptcy (Banai et al., 2013).

Not surprisingly, with longer segments the level of clustering decreased (Chart 52). This is also indicative of institutions being more rigorous in the selection of their counterparties as maturities become longer. Transactions below 1 month still showed the tendency seen in the 1-2 day segment that clustering increased from mid-2010; however, longer segments behaved differently. Apparently, above 1 month and in particular with maturities exceeding 3 months, values around 0 are not uncommon. In other words, triangles or cliques are not formed in the graph. The clustering coefficient also indicates that the longer the maturities, the less the graphs are characterised by the small world property. The average of the average clustering coefficient in longer segments was as follows: 0.11 for 3 days to 1 month, 0.09 for 1 month to 3 months, and 0.07 above 3 months. In this regard, longer

markets are more similar to the random graph. In autumn 2008, a decline in clustering was observed in all maturity segments.

Chart 53: Density in specific segments



Source: Own calculations based on MNB data.

Changes in network structure are also well characterised by the dynamics of the density function. In the 1-2 day segment, at a weekly frequency the indicator remained relatively stable right until summer 2010. As with the other indicators examined so far, the second half of 2010 also marked a turning point here. The significant increase in density may be attributed primarily to the loss of vertices with low degrees. This is because in such cases, while there is hardly any change in the number of connections formed (the numerator), the number of possible connections (the denominator) decreases significantly. The same result is obtained from an analysis of the 1-2 day market at a monthly frequency (Chart 53). The indicator is relatively low at around 4%, which is not uncommon with financial networks. The densities of the networks with various maturities hit their respective lows at the time of the Lehman bankruptcy, which means that the smallest number of connections relative to the possibilities were formed at that time. Subsequently, however, longer segments show significant differences versus the 1-2 day market in terms of both levels and appearance. Most strikingly, the level of density increases as maturities get longer. This is attributable to the fact that as a result of a decrease in size, the number of potential connections, i.e. the nominator will be significantly smaller. Although transactions within 1 month still show

some stability, the indicator moves on an upward trend from 2010 in this segment as well. Moreover, the indicator is much more volatile than with the shortest transactions. A gradual increase was also observed for the two longest segments towards the end of the period under review, but the level reached by the end of the period is not outstandingly high in a historical comparison. In other words, the ratio of the connections formed was not particularly high even with the contraction in network size, despite the fact that the number of possible connections increases at a rate of the size squared. This may be another indication that trust weakened in longer segments as well.

3.6 Conclusion

During the economic crisis that started in 2007, serious disruptions occurred several times in the operation of various financial markets. Certain markets dried up completely, and central bank intervention was needed to ensure that the consequences of their loss caused a minimum amount of damage for the banking system. One particular feature of the crisis was that serious disruptions occurred worldwide even in the secured FX swap market. For that reason, central banks entered into a series of bilateral agreements with one another, temporarily assuming the role of the market. As Banai et al. (2013) demonstrated in the context of the short-term FX swap market, in Hungary the disruptions were clearly shown by the network structure of the market in addition to commonly used market indicators such as implied yield, liquidity indices, and turnover. The particular structural characteristics of the graph of the short-term market occasionally exhibited strong volatility during the crisis. In their analysis of the largest connected component, the authors found that the properties generally satisfied for financial markets were also characteristic of this market. Like other markets, the one-day FX swap market exhibits the small world property, i.e. it is possible to reach any vertex from any vertex in a relatively small number of steps. We have seen that the degree distribution of the network follows power law. Most participants have a relative small number of connections, and there are only few large actors with outstandingly high degrees.

In this study, we aimed to develop an understanding of the properties of networks derived from FX swaps of longer maturities (see the Appendix for a comparative table), and to obtain a picture of the overall market. This also provided us with a more complete picture

of the short-term market. Regarding the short market, one of our findings was that the number of participants decreased significantly, with a particular decline in the activity of marginal actors. Through an analysis of the overall market, we confirmed that this was not attributable to longer transaction maturities, since graph sizes decreased following the start of the crisis in longer markets as well. With the longest markets, however, the type of exiting actors is not certain.

In the one-day market, we have seen that the network was not connected at a daily frequency, and that there were isolated parts even at a weekly frequency. This property was intensified with longer transactions despite the monthly frequency used. At a monthly frequency, often only 60–70% of the vertices formed a connected component. With the longest transactions exceeding 3 months, occasionally only 30% of the actors were connected. During the crisis, this property became particularly pronounced in the case of the longest transactions, which indicates that certain banks had the confidence to enter into long transactions only with a very small group of institutions.

In the case of the short-term market, we have seen the network to exhibit the small world property that is characteristic of financial networks. This also means that the market is especially sensitive to the behaviour of a few actors, which presents a stability risk (Albert et al., 1999; Newman, 2003). The analysis of longer networks showed this small world property to be less prominent. It definitely applied to networks derived from transactions between 3 days and 1 month; however, the graph of transactions above 3 months increasingly approximated a random graph as the crisis developed. As the number of actors decreased, the network became less and less clustered, and groups gradually disappeared. This may indicate increasing distrust among the actors.

In our study, we paid particular attention to the network derived from the overall market regardless of maturities. Although a distinction between maturities was required due to differences in functions, we were also curious to see the behaviour of the graph of the overall market. As expected, the trends observed here followed those of the one-day market, since a vast majority of the transaction volume is associated with that market. This confirmed our assumption that a segmentation of the overall market was reasonable. This enabled us to identify different trends for transactions of different maturities.

4. MODELLING PROBABILITY OF DEFAULT AND OPTIMAL PTI LEVEL BY USING A HOUSEHOLD SURVEY[23]

Risks of household lending are still a major issue in Hungarian banking. Non-performing loans proportion in the portfolio is rising continuously which has a huge social impact. The Magyar Nemzeti Bank collected information about indebted households via a survey in August 2013. By using this information we constructed a model to find those factors which have significant effect on PDs (probability of default) of households' mortgages. We also used this model to calibrate optimal level of household mortgages' PTIs (payment-to-income) which is important from a regulatory point of view. Our results show that denomination of the loan and indebtedness of the household are crucial factors in the performance of the loan. We also showed that loans via agents are riskier than others. The results carry two important messages from a regulatory perspective. Prescribing the same PTI for forint and FX loans may be unnecessarily restrictive for the former, and excessively permissive for the latter. Similarly, the uniform regulation of households with different income levels may also lead to undesired anomalies.

JEL classification: G21, G01, E58

Keywords: FX lending, probability of default, payment-to-income ratio, bank regulation

[23] Balás, Tamás, Ádám Banai and Zsuzsanna Hosszú: Modelling probability of default and optimal PTI level based on a household survey, Acta Oeconomica 2015, vol. 65./2, page 183-209.

4.1 Introduction

The financial crisis starting in 2007 changed the environment of banking systems profoundly, and this did not leave the Hungarian financial intermediary system unscathed. The banking sector responded to the crisis by substantial balance sheet deleveraging, while non-performing portfolios rose to record heights. Despite government measures and banks' efforts, nearly a fifth of the entire household loan portfolio was non-performing at the end of 2013. This level is extremely high in regional comparison even if one off factors like the early repayment scheme also increased it. Therefore it is important to explore the factors that may have contributed to the evolution of this unfavourable development.

Relying on micro data, our research was primarily focused on exploring the macro, socio-demographic and loan characteristic variables that account for the probability of default in the case of Hungarian household mortgage loans. To that end, we applied binary estimation methods, mainly logit models, as modelling tools. Moreover, a key task of our exercise was to examine the relationship between the payment-to-income ratio (PTI) and credit risks. In this framework we attempted to identify the maximum PTI level at which the overindebtedness of households may be still avoided. The latter is not only important from the perspective of households, but may also be a crucial factor for financial stability considerations. Thus, besides serving ground-breaking analytical purposes, our research may provide a sufficient foundation for regulatory authorities to develop measures to preventing the build-up of macroprudential risks.

Our study is structured as follows: after the introduction we provide an overview of the relevant Hungarian and international literature focusing on household lending primarily from the aspect of default. This is followed by the presentation of data used for the purposes of our study and, since a sampling technique is applied in our micro database analysis, we also determine the representativity of our sample (relative to macro data). The chapter to follow includes a detailed description of our model specification, the results gleaned from the estimation and a robustness analysis. A separate chapter is devoted to variables that were excluded from our estimate despite their potential impact on the probability of default, as confirmed by empirical observations. We also offer an explanation for their exclusion. In the last part of our study we discuss the relationship between the

payment-to-income ratio and credit risks before providing a summary of our most important conclusions.

4.2 Related literature

The most important feature of Hungarian mortgage loans to households is its denomination structure, given that, at the beginning of the crisis, 70 per cent of the loan portfolio was denominated in foreign currency, especially in Swiss franc. The reasons for the emergence of foreign currency lending to households have been discussed extensively both in the Hungarian and in the international literature (for example: Zettelmeyer et al. 2010; Király and Banai 2012). Basso et al. (2007) established that, among other factors, an easy access to foreign currency financing, large interest rate differentials between domestic and foreign currencies and the openness of economies all shifted households' focus to foreign currency borrowing. All these factors were prominently present in Hungary at the time, which offers at least some explanation to the extremely high proportion of domestic foreign currency lending. During the crisis, the forint exchange rate depreciated considerably against the Swiss franc, and consequently the performance of the substantial retail FX loan portfolio deteriorated substantially. Factors influencing the performance of loans to households have become the focal point of studies on domestic retail lending.

According to the conclusion of Hosszú (2011), the open exchange rate position of households played a role in the default of retail loans. The paper relies on the cross-sectional micro database of the Household Budget Survey (HBS) compiled by the CSO for the period of 2004–2008 to analyse the consumption patterns and borrowing decisions of households and the heterogeneity of these decisions in various income brackets. It draws conclusions based on the indebtedness and labour market position of households identifying the macroeconomic factors that may have played an important role in the non-performance of certain income strata. According to this database, after the outbreak of the crisis even a slight strengthening of the Swiss franc exchange rate may have resulted in debt-repayment problems in the low-income strata owing to high instalment amounts relative to income, whereas in the case of the medium-income strata the increase in the ratio of non-performing loans may have been caused primarily by loss of employment exacerbated by the depreciation of the HUF/CHF exchange rate. The greatest disadvantage

of the HBS survey compared to that used in this paper is that it offers far less information about the loans granted to households.[24]

In their study, Gáspár and Varga (2011) also used the HBS micro database for modelling loan repayment problems. They assume that a household cannot perform its repayment obligation if its monthly instalment exceeds 40 per cent of its net income (as the remaining 60 per cent should cover basic consumption expenditures). The authors attributed the resulting default to three factors: the initial level of indebtedness (payment-to-income ratio) was already too high; depreciation of the forint exchange rate; loss of employment. Based on their findings, high initial indebtedness and exchange rate changes were responsible for 50 per cent and 45 per cent of defaults, respectively, while unemployment accounted for the remaining, almost negligible percentage. Once again, the use of the HBS implied a disadvantage due to its restricted and non-representative information base on loans (for instance, based on HBS data the household loan portfolio is far smaller than the actual outstanding debt of the sector).

Holló (2009) analysed the risk characteristics of retail mortgage loan portfolios by using panel database of three commercial banks with substantial households' exposure. The applied method in this case was survival analysis, which takes into account that the probability of default is varied in different life cycles of the loan. His findings suggest that the loans' denomination structure, the initial loan-to-value (LTV) ratio and the debtor's level of education can be considered as the main customer- and product-specific drivers of default risk, while the unemployment rate, domestic and foreign interest rates as well as the exchange rate constitute the major macro-risk factors impacting defaults.[25]

Finally, the study by Holló and Papp (2007) is another noteworthy piece of the Hungarian literature. Although this is the oldest of those listed and hence, its conclusions are the farthest from those presented in this analysis, this was the MNB's last household survey comparable to this one. The most important difference between the two surveys lies in the

[24] The HBS introduced the question set related to household loans only in 2010. At the same time, even the surveys compiled in subsequent years do not include data on restructuring or the exchange rate cap. Moreover, regarding the NPL ratio of the banking sector HBS data do not represent households.

[25] Ultimately, the model received was used for stress testing purposes. Its enhanced version is still used in the MNB's solvency stress tests in order to calculate households' default probabilities (the actual model is described in Banai et al. [2013]).

scopes of questions asked, since those have been extended in this study. As a new element, the 2013 survey introduced questions about the value of all real estate owned by the household, not only those used as collateral. Similarly, questions were included in this survey about a possible restructuring and its date, participation in the exchange rate cap and the early repayment scheme and the involvement of a lending intermediary. The authors set out to model the probability of default by using financial margin calculations, logit and neural network approaches. According to their findings, disposable income, the number of dependants, the share of monthly debt servicing costs and the employment status of the head of the household have meaningful explanatory power. The resultant models were used to test the shock-absorbing capacity of the banking system.

The results of the relevant Hungarian literature, so far, can be summed up as follows: Both Hosszú (2011) and Gáspár–Varga (2011) attribute the default of household loans to three main factors: initial debt overhang, loss of employment and a change in the monthly instalment amount. The former merely attempted to explain which factor affected which income bracket the most, while the latter decomposed and quantified the role of each reason in households' non-performance. Since, according to the former paper, excessive indebtedness was most typical in the low income brackets, and the latter pointed out that debt overhang was the most important factor leading to default, low-income households are presumably over-represented within defaulting households. Similarly, the estimates of Holló-Papp (2007) and Holló (2009) reconfirm that all three factors (debt overhang, unemployment and instalment increases) play a relevant role in changes in the probability of default: debt overhang is measured (directly or indirectly) by the loan-to-value ratio (LTV), households' disposable income, the payment-to-income ratio and the number of dependants. The customer's level of education and the labour market position of the head of the household are indicators of the probability of unemployment. Finally, among other things, the denomination structure of loans, domestic and foreign interest rates and changes in the exchange rate can be used to measure the effect exerted by changes in the instalment amount. As will be shown, in our estimates we have established the significance of a similar range of variables.

This analysis, however, goes beyond the limits of previous Hungarian studies in several regards. On the one hand, it distinguishes between various product types and provides

information about the features of loans disbursed in different years. On the other hand, based on the model, it draws relevant conclusions from a regulatory perspective as well.

Performance of household loans is also a common topic in the foreign literature. For example the paper of Blanco and Gimeno (2012) was focusing on this topic in Spain. The analysis – based on the data of the Spanish credit register – have shown that the dynamics of non-performing loans was explained mostly by unemployment, credit stock and a composite measure on instalment burden and revenue. A paper by Lydon and McCarthy (2011) was examining the Irish mortgage market which was hit hard by the crisis. Their results were intuitive since default was explained best by debt service burden and LTV. In addition, labour market position and the purpose of the mortgage (i.e. investment or self-use) were also significant explanatory variables. Among many more Mian and Sufi (2009) was focusing on the mortgage crisis of the US. They found that probability of default increased the most at those places where jump and fall of house prices were the biggest. I.e. the value of the collateral behind the loan influences significantly the probability of repayment.

There are also some examples where default probability was estimated based on similar household surveys, by using binary choice models. May and Tudela (2005) estimated a dynamic probit model for the probability of British households having mortgage payment problems, and based on the results determined which factors had the greatest impact on a debtor's default. During the survey the authors relied on, the same households were interviewed each year; therefore, they had an opportunity to look at the impact of individual factors dynamically. They found that, of all variables under review, becoming unemployed had the largest marginal effect upon the probability of mortgage payment problems. In addition, interest income gearing also had a pronounced effect (interest payments and principal payments relative to income were examined separately). Finally, according to the authors, having unsecured debt and this being a heavy burden on the household significantly increased the probability of having mortgage payment problems. Overall, the ability to repay was equally determined by labour market position and the size of the instalment amount (which depends on indebtedness); in other words, the findings were consistent with those found on Hungarian data.

Finally, La Cava and Simon (2003) drew on data from a household survey to explore variables influencing the performance of loans. For our purposes it is of special importance that the sample used for the logit model estimated by the authors included, similarly to ours, cross-sectional information only. The study was not focused exclusively on the performance of loans, but on the financial difficulties households faced in general. The authors wanted to find out which characteristics increased the probability of a household being financially constrained during the time of their review (at the turn of 1998/99). According to their analysis, a broad range of variables proved to be significant. Besides such variables as unemployment, the size of mortgage repayment, interest payable on credit card debt and income, certain one-off debtor characteristics such as age or household size also had significant explanatory power. In summary, the international literature reveals that binary variable models have been used on several occasions to assess the financial performance of households. In these models, income and labour market position and the level of indebtedness had significant explanatory power in the assessment of households' performance.

4.3 Dataset

In August 2013 the Magyar Nemzeti Bank collected information about indebted households via a questionnaire-based survey. The purpose of the survey was to enable the MNB to gain in-depth information about the financial position, level of indebtedness and saving habits of households. The survey prepared with the assistance of GfK Hungária only involved households where at least one family member had some kind of a loan. The 1,000 households interviewed had a total of 1,322 loan contracts at the time of the survey. Of all loan contracts, housing loans had the largest share in terms of number, with 341 such loans being in the sample. Personal loans (196), overdrafts (176), home equity loans (163), and car purchase loans (138) also had a significant share. The number of student loans (28) and card-based credits (83) was relatively low. The ratio of product types to the total portfolio is nearly identical with the data seen in the banking sector.

It was an important objective of the survey to be representative in several regards: on the one hand, it had to represent households with outstanding loans according to a few important socio-demographical characteristics (such as household composition or the settlement type of the household's residence). On the other hand, the survey had to ensure

that the value of specific products in proportion to the total portfolio should correspond to that seen in the banking sector. Since we have no information on the distribution of indebted households according to social attributes, the results of the survey can only be compared to the distribution of all households. Although this comparison may therefore show some differences, it can still be used as a point of reference.[26] For example, 201 respondents of the 1,000 interviewed reported to live in Budapest, which roughly corresponds to the ratio of Budapest citizens to the total population, i.e. 18 per cent. 251 respondents reported to live in a county set, which slightly exceeded the actual 20 per cent ratio. The 37 per cent ratio of other towns is also somewhat higher than the actual 30 per cent national ratio. Thus, taken together, the ratio received for debtors living in smaller municipalities was smaller than the 30 per cent ratio to total households.

The denomination of loans outstanding is a key question in the case of household loans, given that one of the most important risks of the portfolio is stemming from this feature. With that in mind, we examined the extent to which the currency composition received during the survey corresponded to banking sector data. With one exception, we did not find any significant differences. It was only in the case of housing loans that CHF and JPY denominated loans comprised a larger part of the sample than in reality. Consequently, HUF loans were under-represented. In the case of other product categories we did not discern any significant differences and we can state that, overall, our sample is adequate even from the aspect of currency composition.

Table 4: Distribution of selected credit products by their denomination

Survey (per cent)					Banking system - actual (per cent)				
Denomination	*Housing loans*	*Home equity loans*	*Vehicle loans*	*Personal loans*	**Denomination**	*Housing loans*	*Home equity loans*	*Vehicle loans*	*Personal loans*
HUF	30	11	26	87	HUF	45	18	32	81
EUR	7	11	3	1	EUR	7	9	2	2
CHF	60	78	70	12	CHF and others	48	73	66	17
JPY	3	0	0	0					

Source: MNB and the survey.

Finally, we compared our sample to banking sector data in respect of delinquency as well. This is a particularly important aspect as the primary goal of our analysis is to explore the reasons for the non-performance of household loans. Regarding delinquency, we were

[26] The HBS gives information on the distribution of social characteristics of the households but it is not representative on loans (e.g. non-performing loans). Therefore it cannot be used for our goal.

focusing only on mortgage loans since our analysis was dealing only with their performance. Loans overdue more than 90 days (3 months) deserve special attention because they are considered non-performing loans. Based on this definition, of all products under review, banking sector data and data from the survey were nearly the same. Difference between them amounted to 1 percentage point and 2 percentage points, respectively.

Table 5: Distribution of various credit products

Delinquency (per cent)	Survey		Banking system - actual	
	Housing loans	*Home equity loans*	*Housing loans*	*Home equity loans*
Performing	67	51	75	53
Less than 1 month	8	6	9	12
Between 1-3 months	10	13	4	7
More than 3 months	14	30	13	28

Source: MNB and the survey.

All in all, the biggest advantage of this survey is its representativeness on the structure of the loan portfolio which was not the case for the HBS. The HBS contains detailed questions on household loans only from 2010. Moreover, there is no information on several important characteristics of loans like restructuring or exchange rate cap. Finally, the HBS is not representative on the performance of loans.

4.4 Modelling of default probability[27]

4.4.1 Structure of the model

As the data of the survey are representative, they are suitable both for analysing household loans and for modelling purposes. Although it is important to add that due to the early repayment scheme in 2011 today's portfolio quality in the banking system is somewhat worse than the originally issued portfolio. Most of the households using the early repayment scheme were among the better performing debtors. With our estimates we intended to find out which factors play a relevant role in the default probability of mortgage loans, and we also quantified the effect of each variable. We did not focus on the relation

[27] List of all tried variables in the estimation, correlation between variables, estimation results, model's goodness-of-fit statistics will be available in a future MNB occasional paper (Balás et al [2015]) or can be taken from the authors.

between any specific variable and the probability of default. Our goal was constructing a model which can estimate well the probability of default based on the data of the survey.

The data structure enabled us to estimate cross-sectional, binary choice models. We chose the survey question pertaining to repayment delinquency as our response variable; if the instalment of the specific loan is 90 days past due, our dependent variable will take the value of one, otherwise it will be zero. A delinquency of over 90 days is customarily considered in the literature as a non-performing contract, and we followed the same practice. Having said that, due to the limitations of the data available, our interpretation of the probability of default (hereinafter abbreviated as PD) somewhat differs from the usual concept in respect of time horizon. The estimated or projected PD values usually refer to becoming non-performing within a year. Since the database we relied on does not contain specific information about when exactly the debtor fell 90+ days delinquent and we performed the estimate in a cross-sectional structure, instead of PD within a year, our estimated PD values capture the probability of default from the disbursement of the loan to the date of sampling. Consequently, below we will refer to this value as long-term PD. The disadvantage of this definition is that elapsed time since the issuance of these loans differs significantly in some cases (the oldest contract was made in 1978 and the youngest one in 2013). It is a general observation about mortgage loans that, from the perspective of becoming delinquent, the first 5 years of the term are critical. Indeed, loans which remain performing during the first 5 years are highly unlikely to fall delinquent later.

20 per cent of the sample consists of contracts dated after 2008, and since not even the riskiest first 5 years have passed since then, the ratio of non-performing loans within this group may be smaller (with all else being equal) for this reason alone. Similarly, the observed default rate may be significantly lower than the actual value in the case of loans older than ten years, given that for some customers who defaulted at the beginning of the loan's maturity even the post-default stage may have ended already. However, the exclusion of the pre-2004 and post-2008 parts of the sample would entail the loss of valuable information: we would be forced to exclude 35 per cent of observations, including 69 per cent of HUF loans. Based on these considerations we decided to use the entire sample as long as there are no major differences between estimates received for the sample limited to the 2004–2008 period and for the total sample.

Since the sample included some households with more than one mortgage loans, we may have performed estimates either on contract-level or on household-level data. We decided to do the former for two reasons: on the one hand, contract-level data produced a larger sample size; on the other hand, we found some examples where one of the household's loans had become 90 days past due already, while there were no payment problems with the other loan. This situation could not have been addressed properly if household-level data had been used.

$$y(0 = performing, 1 = default) = G(\beta_0 + \beta_1 * indebtedness + \beta_2 * income + \beta_3 * labour\ market\ activity + \beta_4 * household\ expenditure + \beta_5 * loan\ characteristics\ dummy + \beta_6 * household\ characteristics\ dummy)$$

where $G(x) = \frac{e^x}{1+e^x}$

We defined six variable group which might have significant effect on the probability of default: indebtedness of the household, income position of the households, labour market activity of the households, spending (not instalments) of households, characteristics of the loan contract, social characteristics of the households. There are several opportunities to measure these factors. E.g. different ratios can grab the labour market position of the household. In many cases these variables contains the same information (on PDs) but sometimes variables representing the same group can have relevant additional information comparing to each other. We will use then the following strategy: we will keep the most significant variable of each group but other significant variables from the same group can be kept as well. Regarding the six variable group in case of the 'indebtedness' our expectation was unambiguously a positive sign, i.e. higher indebtedness results a higher probability of default. Instalment (starting, actual, PTI and per capita), LTV, loan size and instalment of other loans were tried in this variable group. Income of the household also should be important since higher income has to result a lower default probability ceteris paribus. This factor was taken into consideration by two variables, namely income of the household and income per capita. Our expectation for the labour market activity of the household was similar as in case of income. Improving situation on the labour market – measured by the proportion of income earners active on the labour market - decreases the probability of default. Rising expenditures decreases the amount can be used for debt servicing which will result a higher probability of default. Characteristics of households

and loan contracts can vary significantly so the expected signs are unambiguous. The most important loan characteristics were denomination (probability of default is expected to be higher for FX), loan type (home equity loans perform worse), date of issuance (loans of 2007-08 are riskier), LTV above 100 per cent (higher risks), contracts via agents (higher PD is expected). Finally the following household characteristics were considered: higher level of education may result lower PD; higher PD was expected in case of smaller settlement types; finally households with savings were expected to be less risky.

The final version of the model presented here includes only the explanatory variables that proved to be significant at the 5 per cent level. We will use this model in the later calculations. Of the binary variable estimation procedures we chose the logit estimate, and in order to validate the robustness of the method we also applied a linear probability model to the explanatory variables received. Based on the correlation between explanatory variables in the model the existence of extreme multicollinearity can be rejected.

4.4.2 Partial effects

Ultimately, of all the listed variables seven explanatory variables proved to be significant (in addition to the constant variable). Since (contrary to the linear probability model) partial effects differ for each observation in the case of logit estimates, we indicated the average partial effects customarily used in the literature. On the basis of Hosmer-Lemeshow test we cannot rule out the model's goodness of fit at either customary significance level.

Table 6: Partial effects and significance levels of the estimated model's variables[28]

Variable	Average parcial effect (percentage point)		
	Logit	Logit 2004-2008	Linear
Constant	-19.24***	-29.28***	-2.19
Ratio of income earners to household members	-8.14***	-8.53***	-7.85***
Payment-to-income	0.76***	0.89***	1.26***
FX-denominated	5.70**	7.90*	2.96
Payment-to-income belonging to other loans	0.24***	0.28***	0.24***
Instalment per income earner	3.05***	-3.45***	-3.97***
Non-instalment expenditures	0.21**	0.25***	0.33***
Loan via agents	5.46***	7.53***	5.63**

Looking at the characteristics of households among the variables that proved to be significant, the 'ratio of income earners to household members' measures the composition of households according to labour market activity and income position. According to the estimate, more income earners within the same household reduce the probability of default proportionately. This can be quantified as follows: if, *ceteris paribus*, the number of income earners increase from 2 to 3 within a 4-member household, long-term PD will decline by 8.14 percentage points (on average the half of the members of a household has income).

The payment-to-income ratio (PTI) measures the burden incurred by the household in repaying the loan amount, the level of indebtedness. In this context it should be noted that, although the questions of the survey included one pertaining to the household's income, in many cases no appreciable responses were received. At the same time, a detailed set of questions referred to households' expenditures and savings, the net result of which (including, in theory, monthly instalments) captures income. Since the level of completion of these parts was higher, we used this artificial variable to approximate the income of the household concerned. Moreover, for the purposes of our estimate we used the household's actual PTI as at August 2013 (in the lack of income data, the initial PTI value was not available). Based on the results, the greater a household's debt in proportion to its income, the higher the long-term PD of its loan; i.e. a 1 percentage point increase in PTI will increase the long-term PD by 0.76 percentage points on average (with all else being equal).

[28] The stars in the table mark significance levels: one star indicates variables significant at 10 per cent, while two and three stars indicate 5 per cent and 1 per cent significance levels, respectively.

According to the estimate, the risk associated with a loan will be greater if the household has debt service on other loans as well. This effect is captured by the variable 'payment-to-income ratio for other loans'. The average partial effect of this variable (0.24 percentage points) is smaller than that of the other PTI variable. This may be due to the fact that other loans also include unsecured loans, and if a household fails to pay the debt service on its secured loan and on its unsecured loan at the same time, it will be inclined to fall delinquent with the unsecured loan. Consequently, indebtedness with unsecured loans deteriorates the payment discipline observed in the case of secured loans to a lesser degree. The ability to repay is not only influenced by instalment-type expenditures. Households with higher other (non-instalment) expenditures (e.g. food, dwelling, durable and semi-durable goods, etc.) also face a higher probability of default. A HUF 10,000 difference in expenditures will raise the value of long-term PD, *ceteris paribus*, by 0.21 percentage points on average.

The results presented so far are completely consistent with economic intuition in terms of their positive or negative sign. By contrast, it might be surprising that the variable 'instalment per income earner' has a negative sign; in other words, a higher instalment amount will induce a lower PD value. This variable, however, does not capture the indebtedness of the household: according to the definition of the partial effect, an increase in the instalment amount, *ceteris paribus*, reduces long-term PD. Since the rest of the variables include PTI, all else can only be equal if the higher instalment amount is coupled with higher income. Therefore, instead of indebtedness, this variable is much more likely to capture income position or, instead of the instalment amount it measures the instalment amount that a household is capable of paying.[29] In consideration of this, the negative sign of the partial effect is understandable. To confirm this view we also estimated our model excluding the PTI variable. This way the partial effect of the instalment per income earner became positive, i.e. it grabs the indebtedness now.

In respect of the features of the loan, two variables proved to be significant in the estimate. Firstly, foreign currency loans are riskier than forint-denominated loans (owing to exchange

[29] As has been mentioned, we could only approximate the household's income position by means of an artificial income variable; it must have been due to the lack of an actual income variable that 'instalment per income earner' gained such a meaning.

rate driven instalment increases); specifically, foreign currency denomination raises long-term PD by 5.7 percentage points on average. In addition to the depreciation of the exchange rate it might be the result of unilateral raise of interest rates by banks which was very common in case of FX loans. It also increased the debt service burden of loans. Secondly, compared to directly disbursed bank loans, the default probability of loans via agents, *ceteris paribus*, is 5.46 per cent higher on average. Probably, riskiness of loans via agents can stem from the fact that agents' relation with their customers is usually shorter and smaller than that of bank officials. Their motivational methods are also different. Therefore asymmetric information problem is bigger than in case of other contracts.

4.4.3 Robustness analysis

As we have mentioned before, in order to exclude the possible distortions stemming from the different years of disbursement, we have also applied the estimation on a more restricted, relatively homogeneous sample (2004-2008). The partial effects are completely consistent with each other on both samples in terms of their signs, and the same is true for the set of variables significant at the 10 per cent level[30]. Except for the foreign currency dummy, the two models select the same variables even at the 5 per cent significance level. In absolute value, the degree of average partial effects is somewhat higher for all variables in the reduced sample, but more noteworthy differences can be observed in the case of the two dummy variables. In case of the FX dummy this was to be expected in any event, given that the instalment increases stemming from the volatility of the exchange rate were significantly higher for loans disbursed during this period than for those disbursed later. (The estimation of FX dummy on the shorter sample is more uncertain since the proportion of HUF loans was much smaller during that period). The level of these differences, however, did not warrant, in our opinion, the restriction of the sample. (We have also examined the difference between loans with different disbursement years by using another approach, which is discussed later in the study, but we could not identify any significant effect in that case either).

[30] To calculate the levels of significance, we applied White's heteroscedasticity-consistent robust standard errors.

In order to validate the robustness of the results from the aspect of the estimation procedure, we prepared an estimate with a linear probability model as well, which included the variables found significant by the logit models. Except for the FX dummy, the linear model also found all variables significant at the 5 per cent level. Partial effects are completely identical in terms of their signs; as regards their magnitude, they exhibit more substantial differences in two cases: in case of the FX dummy and the PTI. In the first case the linear model has a lower value; in the second case the model estimates a higher partial effect. Since the PTI in the estimate pertains to the time of the survey rather than the situation as at loan disbursement (on which no information is available), the effect of the exchange rate depreciation is reflected in the PTI as well. Thus the PTI of FX loans is higher in the sample than that of forint loans. This may account for the difference observed between the partial effects of the two models; in other words, in the case of FX loans the risk stemming from exchange rate changes is mainly reflected in the FX dummy in the logit model, and in the PTI in the linear model. Therefore, the results of the model proved to be robust from this aspect as well.

4.5 Excluded variables

4.5.1 Housing loan vs. home equity loan

Several variables that should have a good explanatory power based on observations are excluded from the model. The dummy variable pertaining to the different product types did not prove to be significant, although, based on the statistics on non-performing loans, there is a significant difference in terms of the performance of the two product categories. While the share of non-performing loans within the housing loan portfolio was below 15 per cent at the end of 2013, this rate approached 30 per cent in the case of home equity loans. This difference is only partly explained by the fact that there are hardly any forint-denominated loans among home equity loans, while forint loans have a substantial share in housing loans. If we only look at FX denominated home equity loans, the difference between NPL ratios is still significant: the share of NPLs in the total portfolio is 18 per cent for housing loans and close to 30 per cent for home equity loans.

The difference above indicates that product type may have a significant impact on the probability of default. We examined why, in spite of this, the product dummy had no

significant explanatory power in our model. We identified the factors which may influence the probability of default yet are markedly different in the case of the two different products. The first such factor is the currency mismatch mentioned above (only 54 per cent of all housing loans are denominated in foreign currency, while this ratio is above 80 per cent in the case of home equity loans). This, however, does not explain the difference in the performance of foreign currency denominated loans for these two products. Looking at these two products separately, we find additional factors exhibiting significant differences that increase the probability of default, and we consider them, in some way, in our model. The first such variable is average PTI. The PTI value of housing loans is 27 per cent, while the same ratio was 33 per cent for home equity loans. A higher PTI value increases the probability of default. The risk of debtors with home equity loans was also increased by having other, unsecured loans, which, in their case, was more typical. Being an additional burden, this reduced their ability to repay in and of itself. In addition, it is also important to consider that having the rescue package for foreign currency debtors on the agenda reduced debtors' willingness to repay even further if they also had other loans, as the suspension of instalments may have enabled them to repay their unsecured loans. The evolution of the average LTV (loan-to-value) ratio is another important characteristic of individual loan categories. Although this variable has not been included in the model directly, this effect is partly reflected through the instalment amount. In the case of home equity loans, the average LTV value of the portfolio is 17 percentage points higher than that recorded for housing loans, i.e. the size of the loans was bigger relative to the collateral. While a higher LTV ratio is less of a decisive factor in Hungary for willingness to repay, it is still considered to increase risk. In addition, borrowers' heterogeneous savings position also implies a difference. 12 per cent of housing loan borrowers has financial savings, compared to 5 per cent of home equity loan borrowers.

Table 7: Selected features of home equity loans and housing loans

per cent	LTV	PTI	Characteristics of the household					
			With other uncollateralized loan	With savings	Ratio of income earners (per cent)	Ratio of income earners active on labour market (per cent)	Disposable income (HUF)	Income per capita (HUF)
Housing loans	61	27	29	12	61	54	245,482	76,219
Home equity loans	78	33	33	5	61	46	225,459	68,607
Housing loans (FX)	82	33	31	12	62	54	260,858	79,410
Home equity loans (FX)	92	37	36	3	63	46	230,482	69,884

Source: The survey.

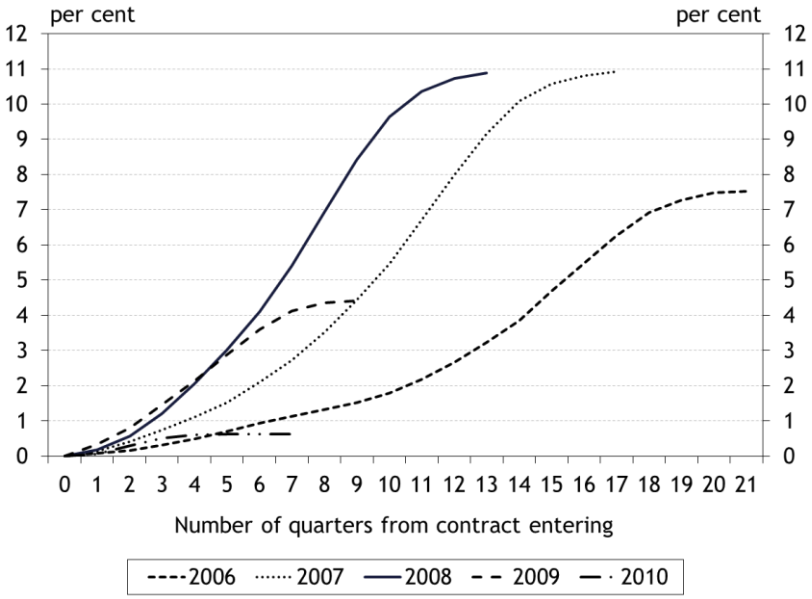
There is a difference between the two loan categories in terms of the borrowers' labour market position as well. Although the ratio of income earners does not differ for indebted households across individual products, the ratio of active earners is higher for those with housing loans. An explanation for the difference in PTI is that disposable income is significantly higher for housing loan borrowers than for home equity loan borrowers. A similar difference can be observed in respect of per capita income. Per capita income is substantially higher for borrowers with housing loans. In conclusion, home equity loan borrowers were, overall, riskier customers based on their labour market position and the relative size of their loans. Accordingly, these factors are included in our model as significant explanatory variables for non-performance.

4.5.2 'Vintage' effect

Besides product type, the date of disbursement should also have a significant explanatory power based on intuitions. On the one hand, thanks to banks' high risk tolerance – as well as consumer behaviour – a much broader range of households had access to loans during the time of the upsurge in FX lending and the build-up of the FX-denominated mortgage portfolio (2004-2008) than in the years preceding or following this period. Thus, foreign currency denomination was not the only reason for the higher rate of loans' non-performance during this period. On the other hand, some analyses on domestic retail lending pointed out that even within this period there was a difference in terms of the average performance of loans: directly preceding the crisis, during the period between 2007 and 2008 banks tended to grant loans to increasingly risky customers, deteriorating the quality of the portfolio progressively. This is demonstrated by the chart published in the

November 2011 issue of the *Report on Financial Stability* (MNB 2011) analysing the performance of loans issued in different years. While non-performing loans within loans disbursed in 2006 reached the 7.5 per cent ratio after 5 years, this ratio was 11 per cent after 4 years already in the case of loans disbursed in 2007, and in the case of those issued in 2008 non-performing loans reached this 11 per cent ratio after 3 years. This demonstrates that loans to households have indeed become increasingly risky.

Chart 54: NPL ratio of FX denominated mortgage loans disbursed in different periods



Source: MNB.

Despite all this, the dummy variable representing the different periods did not prove to be significant in the model prepared by us; therefore, it is worth examining the characteristics of loans issued during the different periods. Although the survey included loans disbursed before 2004 and after 2008 as well, we examined the 'vintage' effect during the most intense period of household lending, the period between 2004 and 2008. We even split this period into two: one just preceding the crisis, the 2007–2008 period and the period of the start of the surge: 2004–2006. For these two periods we examined the strength of the vintage effect by inserting dummy variables into the total sample (one that took the value of one in case of disbursement in 2004–2006 and one for disbursement in the period of 2007–2008) and also by considering the restricted sample for the period of 2004–2008 only (and applied dummies for the period of 2007–2008 only), but we found that the variable(s) were not significant in either case.

Also in this case, we examined the main characteristics of the contracts concluded in the specific periods for the product breakdown. The first significant difference is that average loan size increased by more than HUF 1 million during the period immediately preceding the crisis compared to the previous period. There is no significant difference in maturities between the two periods; however, the slight increase observed in this case points to increased lending risks. Denomination was a possible explanation not only for the performance difference between the different products, but also for that between different vintages. It is clear that the share of foreign currency loans increased further within loans disbursed in the period of 2007–2008, considerably exceeding the already high 72 per cent characterising the 2004–2006 period. We could see that the size of loans in the second period exceeded substantially the value characterising the first period. This information, in and of itself, merely suggests that the risk associated with the loans increased. The LTV and PTI data confirm this assumption. Both the average PTI and the average LTV values were significantly higher in the second period than in the first one. Finally, we also examined how typical it was to take out other, unsecured loans in these two groups. While there is no material difference between the two figures, the second period performs slightly worse in this case.

Table 8: Selected features of loans disbursed in the two review periods

	Loan size (HUF million)	Maturity (year)	Proportion of FX loans (per cent)	LTV (per cent)	PTI (per cent)	Having also loans with no collateral (per cent)	Ratio of income earners (per cent)	Ratio of income earners active on labour market (per cent)	Disposable income (HUF)	Income per capita (HUF)
2004-2006	4.23	18	72	64	27	30	56	47	241,693	71,966
2007-2008	5.51	20	84	88	36	33	62	52	240,146	69,964

Source: The survey.

We examined whether there was a difference in the labour market situation of borrowers in the case of loans disbursed during the two different periods. In this regard, a relatively small difference was observed between the two groups, and the direction of the differences is not straightforward. While the ratio of active employees within the family is slightly higher among the borrowers of the second period, disposable income is smaller, both as an absolute number and as a per capita figure. The difference, however, is very low in both cases. Thus, labour market position may not be considered significantly different in the two groups. Finally we have to add that the initial exchange rate may also be a difference

between the two periods. Especially in 2008 the HUF was very strong. While the average HUF/CHF exchange rate for the period 2004-06 was 163, for 2007-08 it was lower around 155. This factor may have some influence on the difference between the performances of the two periods.

We can see, overall, that it was not the different labour market situation that meant the main difference between the loans of these two periods but the borrower's level of indebtedness after the disbursement of the loan, which supports the findings of Gáspár and Varga (2011). However, as the other variables integrated into the model (foreign currency dummy, PTI) capture the explored differences, it is understandable that the vintage dummy cannot be significant.

4.5.3 Other excluded variables

The exclusion of the two variables described so far required the most detailed presentation; however, we included some other variables in the database and tested their effects during the modelling exercise, but they did not prove to be significant. It is noteworthy to take account of them and explore the possible reasons for their exclusion. One of the most frequently used indicators capturing credit risk is the loan-to-value (LTV) ratio. The LTV expresses the size of the loan which also refers, implicitly, to the size of the instalment. And a high instalment amount increases the probability of default. In addition, a high LTV can also have a negative impact on willingness to repay; indeed, if the loan is worth more than the real estate collateral, it may be worth letting it default. In view of this, we tried to consider the possible effects of the LTV in two ways: as a continuous variable, the LTV itself was also included in the model; in addition, we introduced a dummy variable which took the value of one when the LTV rose above 100 per cent (i.e. when the collateral is worth less than the borrower's debt), otherwise it was zero. Behind the latter is the consideration that the deterioration of the willingness to repay is not necessarily in a linear relationship with changes in the LTV; it is more like a psychological threshold (with the obvious value of 100 per cent) that, once it is reached, may deteriorate drastically. The effect stemming from the relatively high instalment amount is not relevant in our model because this impact mechanism is captured by the PTI variable far more clearly and unambiguously. The second problem, in our case, is also irrelevant as, on the one hand,

there is no private bankruptcy in Hungary and on the other hand, borrowers principally used their own residential property as collateral for the loans. The ratio of mortgage loans where the loan's collateral was not the residential property was only 2 per cent in the sample. Thus choosing default is not a real option for borrowers.

Education often has significant explanatory power in respect of the default probability of loans. Nevertheless, this variable did not prove to be significant in our model (the reference category was elementary school education at the most; higher education levels were included in the model in the form of three dummy variables). This is because the education level, in reality, captures better labour market position and better income conditions. These factors, however, are already included, firstly in the share of income earners within the household, secondly by the PTI and thirdly, by the per capita instalment amount. It can be explained by a similar logic that the dummy variables expressing settlement types (county seat, town with county rights, other towns and smaller municipalities – with Budapest being the reference category) did not prove to have significant explanatory power.

Finally, participation in the exchange rate cap scheme was also excluded from the explanatory variables. This may have been insignificant because the exchange rate cap has a relatively short history in Hungary for the time being. Indeed, at the time of taking the survey, the scheme was hardly one year old. Usually, the restructuring of loans takes place because of some payment problem; however, despite the restructuring, such loans are more likely to become non-performing again than problem-free loans. Therefore, we also included a dummy for restructuring in the model, which eventually did not prove to be significant. This may be because loans subject to restructuring had been riskier to begin with, but this risk is already captured by the variables included in the model, thus the mere fact of restructuring does not carry any additional information.

4.6 Relationship between the payment-to-income ratio and credit risk

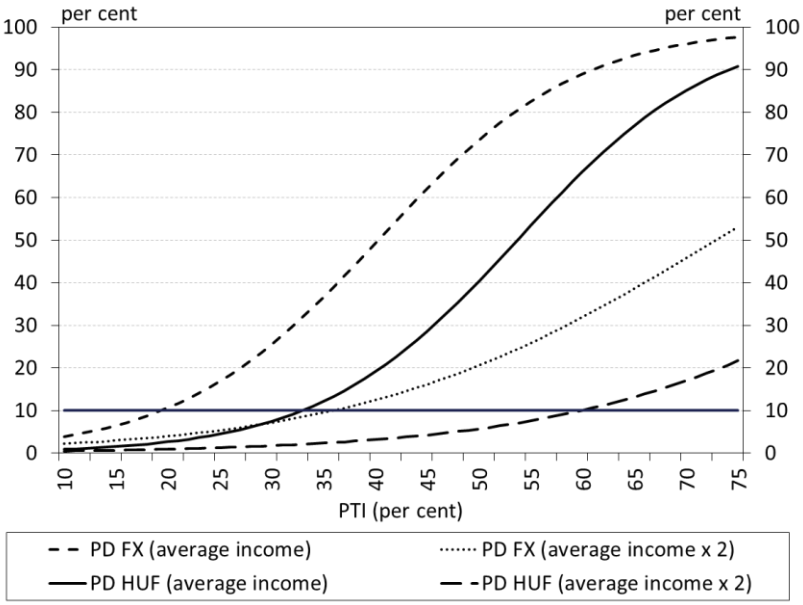
Of the explanatory variables of the model presented above it is important to examine the payment-to-income ratio separately. PTI is used by the regulatory authorities of banks in several countries (including Hungary). Regulations pertaining to the PTI typically prescribe a limit which must not be exceeded by the PTI of disbursed loans. This, on the one hand, is designed to prevent borrowers from taking excessive burdens and, on the other hand, to limit, at least in part, the credit risks taken by the banking sector. At the same time, a PTI

limit that is lower than justified restricts unnecessarily households' access to loans and hence, impairs the efficient functioning and growth of the economy. At the beginning of the 2000s several countries introduced PTI regulations in order to curb excessive credit expansion and prevent the build-up of systemic risks. In the cases known (e.g. in China, Korea and Romania) the regulatory authorities deemed this step a success, although usually this was introduced as part of a bigger package, thus its individual effect is hard to assess (Borio et al. 2007). In the Hungarian literature we can also find papers which were dealing with the regulation of PTI. Berlinger-Walter (2013) after analysing the mortgage loan portfolio describe „repayment burden" – that is PTI – as the most important systemic risk factor. They also analyse the different economic factors affecting PTI (net income, exchange rate, interest rate). In their income contingent repayment proposal the main objective is to reduce this "repayment burden" significantly and easing systemic risk.

Therefore it is important to examine the relationship between a loan's long-term PD and the borrowing household's PTI, and to identify the PTI values which mark excessive risk-taking in the case of a loan. Based on our model estimates we attempted to clarify this issue with the help of the data and methodology available to us.[31] We calculated developments in a household's long-term PD in function of the PTI in case of a foreign currency loan and in case of a HUF-denominated loan. For the purposes of this exercise we used a representative household that could be considered, based on the sample and other information, to be average. The household was average in terms of the other variables of the model: it consisted of four members with two wage earners; their income was the same as the net average income of the national economy. The household's payment-to-income ratio for other loans was 6 per cent and it spent 75 per cent of its total income on consumption. With a probability of 22 per cent for forint loans and 32 per cent for FX loans, their loan was intermediated. And per capita instalment amount can be derived from the different PTI values.

[31] We must note, however, that there is a difference between the PTI prescribed by authorities and the PTI used in our model: the regulation always pertains to the initial PTI at the time of loan disbursement, while in our estimate we used the household's actual PTI as at the time of the survey (as this was the only information we had). There may be a considerable difference between the two due to changes in the exchange rate, interest rate and income. In our opinion, however, this does not have a material distorting effect on the results presented.

Chart 55: Long-term PD in function of the PTI with different denominations and income

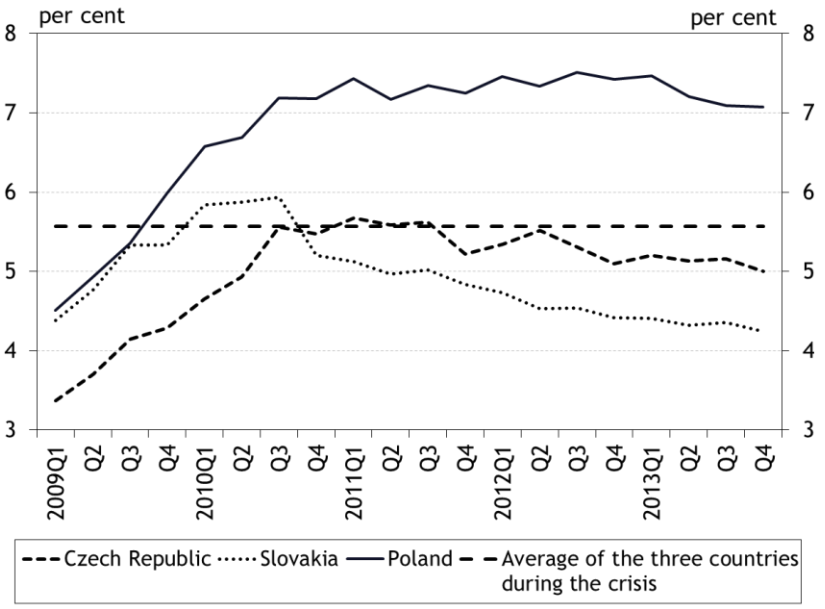


The values thus received are shown on Chart 55. The question arises what exactly is the long-term PD level that does not point to excessive risk-taking (assuming the natural functioning of the banking system). In our sample, the total loan portfolio comprises 10 currently non-performing loans in the case of housing loans, while non-performing loans account for 17 per cent of the portfolio in the case of home equity loans. This observation, however, pertains to a period that was characterised by higher than desirable lending risks and the excessive indebtedness of borrowers (which is reflected, even in our days, in soaring and historically high banking sector NPL rates and the payment burdens of foreign currency debtors). Thus, the desirable PD value is lower than this.

In order to determine this value more precisely, we performed a calculation based on simple rules of thumb. The high NPL rate (around 20 per cent) currently characterising mortgage loans was induced by high probabilities of default, the declining loan portfolio and the low portfolio cleaning rates. From a simple calculation we can deduce that, in the context of the assumptions of a normal business cycle, the current banking sector NPL ratio would be about 5–6 per cent in the case of mortgage loans. For the purposes of the calculation we considered a 10-year period where the loan portfolio grows by 5.5 per cent annually (corresponding to the rate of nominal GDP growth in case of 2.5 per cent real growth and a 3 per cent inflation rate), the probability of default (i.e. the customary PD) is 1.5 per cent and the quarterly cleaning rate is 5 per cent. As a result of this calculation, the

NPL ratio would be around 5.5 per cent after 10 years, implying a risk of manageable size for the banking sector. This view is supported by several factors.

Chart 56: NPL ratio in the region during the crisis



Source: ECB.

We have checked the household NPL ratio for the last few years in the other Visegrad countries which were performing much better than Hungary. The average level was around 5.6 per cent *(*Chart 56*)*. Beside this the NPL ratio of state subsided HUF mortgages was around 4.5-5 per cent during the crisis which also confirms our view that this is a tolerable level. Faster growth of loan stock or better cleaning activity may result a lower ratio but our goal was finding an acceptable maximum level.

It is due to the specificities of the sample that we could not consider cleaning, irrespective of how long the specific loan has been delinquent. Moreover, in our sample we could not reckon with a growth of the portfolio either. Considering all these factors, the tolerable NPL ratio would be about 10–11 per cent within the portfolio (mainly due to the lack of cleaning)[32]. The latter shows how big the actual non-performance ratio would have been in our sample in the context of normal risk appetite and with all other conditions being unchanged. Since this is the realised value of the PD definition used for our estimate in the sample average, for the rest of our study we consider this 10 per cent long-term PD to be

[32] Indeed, our sample implicitly assumes that there is no cleaning.

the risk taking that is still tolerable for the regulator (this 10 per cent long-term PD level is highlighted on Chart 2).

When HUF and FX denominated loans are compared to one another, the two loan categories may be considered to have identical risk (in terms of non-performance) in the context of extremely different PTI values. In the case of forint loans, a 38 per cent PTI, while in the case of FX loans a 24 per cent PTI is consistent with the aforementioned 10 per cent long-term PD value. Therefore, during the review period an average household's indebtedness in foreign currency increased long-term PD to a degree corresponding to a 14 per cent increase in PTI. This difference can be considered significant even if we know that some of it can be explained by unilateral interest rate hike.

In addition to currency denomination, we also examined the relationship between the probability of default and the payment-to-income ratio in function of the household's income. As households' income increases, they typically spend less and less on consumption: while the consumption rate is often 100 per cent in the case of low-income households, households with higher income can accumulate substantial savings. Thus, an increase in income also increases the PTI that can be tolerated by the household. Chart 2 indicates how long-term PD changes in function of the PTI if the household's income is twice the amount of the net average income. Table 9 sums up the PTI values belonging to the 10 per cent long-term PD and various household income brackets. Accordingly, in case of a household with a forint loan and average income, even a 20 percent higher PTI would not imply excessive indebtedness if the household's income was doubled. While in the case of foreign currency loans this value is smaller – 10 per cent –, it can still be considered high.

Table 9: PTI values belonging to the 10 per cent long-term PD of an average household in the context of different incomes and denominations (total loans)

per cent	100,000 HUF	150,000 HUF	200,000 HUF	250,000 HUF	300,000 HUF
HUF	34	38	42	49	59
FX	22	24	26	30	35

Our sample is heterogeneous on the start of the contract (and for this reason macroeconomic and regulatory conditions as well) we have made these calculations for the period of 2004-08 (among the robustness tests we have shown this model as well and it could be also seen that the two models were very similar). Table 10 summarizes the results.

Comparing these numbers with the results in Table 9 it is clear that there is no significant difference in case of FX loans. Regarding HUF loans we got higher PTIs for the shorter sample by 7-9 percentage points. Since most of the FX loans (83 per cent of them) were issued in the period 2004-08 getting similar results for the two models is not surprising. In case of HUF loans only 36 per cent of the sample was in the shorter period so we lose a lot of information on them in this model. In case of HUF loans we think that the model on the whole sample gives better results then.

Table 10: PTI values belonging to the 10 per cent long-term PD of an average household in the context of different incomes and denominations (2004-2008)

per cent	100,000 HUF	150,000 HUF	200,000 HUF	250,000 HUF	300,000 HUF
HUF	41	45	51	58	69
FX	22	24	26	30	35

Our results carry an important message from a regulatory perspective; prescribing the same PTI for forint and FX loans may be unnecessarily restrictive for the former, and excessively permissive for the latter. A similar conclusion can be drawn about the uniform regulations pertaining to households in different income brackets. It would be therefore reasonable to introduce a distinction, and apply different PTI limits for different denominations and income levels. Obviously, the values indicated above imply desirable average levels over the long term. When the economy and the credit market show signs of overheating, there is a higher risk of overly permissive regulations, while during a recession and in the context of a credit crunch the risk of excessively stringent PTI regulations is higher. Accordingly, the regulator should also consider developments in the economic and lending cycle and also the interest rate dynamics.

4.7 Conclusions

We estimated the probability of default of Hungarian households with the help of a representative questionnaire-based survey. The data structure enabled us to use cross-sectional, binary choice models. We used the survey question pertaining to repayment delinquency as our response variable and considered the specific loan non-performing if the instalment was 90 days past due. In the model received as the final specification, the signs and magnitude of the variables were consistent with economic intuitions. The results proved to be robust to model specification, i.e., whether to include vintage effects and non-linearity.

Of the features that purely characterise households, only one variable proved to be significant: the 'ratio of income earners to total household members', which captures the household's labour market activity and its composition according to income position. According to the estimate, more income earners within the same household reduce the probability of default proportionately.

As regards the features of the loan, two variables proved to be significant in the estimate: firstly, foreign currency loans are riskier than forint loans. Secondly, compared to directly disbursed bank loans, the default probability of loans via agents is higher.

As regards the rest of the indicators, 4 factors proved to have significant explanatory power. The PTI level measures the burden incurred by the household in repaying the loan amount, the level of indebtedness. The higher a household's indebtedness in proportion to its income (PTI), the higher the long-term PD of its loan. According to the estimate, the risk associated with a loan will be also greater if the household has debt service on other loans as well. This effect is captured by the variable 'payment-to-income ratio for other loans'. The ability to repay is not only influenced by instalments. Households with a higher level of 'expenditures above the instalment amount' also face a higher probability of default. Finally, 'per capita instalment amount' proved to be significant as well; however, the sign of the variable is negative. This means that a higher instalment amount induces lower long-term PD. Instead of indebtedness, this variable primarily captures income position and in line with this, instead of the instalment amount it measures the instalment amount that a household is capable of paying. In consideration of this, the negative sign of the partial effect is understandable.

During our estimates we have also tested several variables which were not included in the final model (due to their insignificant effect), even though they may have considerable explanatory power based on empirical experiences. We demonstrated, however, that the effects reflected in them are captured by other indicators that proved to be significant in our model. For instance, distinguishing on the basis of loan purpose we can establish that home equity loans perform worse than housing loans. This, however, is due to the fact that households with home equity loans are more indebted with worse income and labour market positions. The situation is similar when we compare loans disbursed in the periods

of 2004–2006 and 2007–2008: debtors' higher indebtedness explains the higher non-performance rate of loans disbursed during the latter period.

Based on the model estimated we examined the relationship between PTI and the probability of default in case of different loan denominations and different household incomes. The results carry two important messages from a regulatory perspective. Prescribing the same PTI for forint and FX loans may be unnecessarily restrictive for the former, and excessively permissive for the latter. Similarly, the uniform regulation of households with different income levels may also lead to undesired anomalies. In order to avoid this, a potential new PTI regulation should differentiate between loans based on denomination and between households based on income levels.

5. DRIVERS OF BANK LENDING IN HUNGARY – ROLES OF BANK-SPECIFIC AND MACRO FACTORS[33]

The lending activity of the Hungarian banking system is still subdued six years after the onset of the crisis. We construct a novel panel dataset with data on 11 Hungarian banks from 1999 to 2013 to examine the main bank-specific reasons behind this trend. We find that on a longer horizon, sound funding positions (i.e. loan to deposit ratio) support lending activity. Moreover, other types of liquidity risk, such as reliance on FX swap market, also have negative effects on loan growth. Foreign ownership in itself does not have a significant impact on lending, but parent group characteristics can affect the lending activity of subsidiaries. Banks with a more profitable, better capitalized parent group with a safer funding position tend to lend more in Hungary. The crisis changed these relationships to some extent. After 2009, solvency measures became more crucial in lending activity and the significance of liquidity measures decreased somewhat. We also find that the effect of demand side factors became more significant in the crisis than before.

Keywords: bank lending flows, bank level data, financial crisis, Hungarian banking system

JEL codes: E44, E51, G21, G28

[33] Banai, Ádám (publication in Hungarian): A banki hitelezést meghatározó tényezők - középpontban a bankok helyzete és a makrokörnyezet, Közgazdasági Szemle, Vol. LXIII., February 2016 pages 137—161. DOI:10.18414

5.1 Introduction

The transition of the banking system in the CEE region was completed by the start of the new millennium. As a result, the banking systems of all of countries in the region had a very similar ownership structure, dominated by foreign banks. As Banai et al. (2010a) states, the accession of these foreign players was important not only because they brought capital and funding to the region, but also because they ensured banking know-how for their activity in the region. Stemming from these sources, a fast convergence process started in the states of the region, and expansive lending dynamics became observable. Favorable global liquidity conditions supported the growth of these banking systems. Although the evolution of banking was very similar throughout the region, the crisis affected individual states differently in many ways. After the onset of the crisis, bank lending to the private sector in the CEE region started to shrink at a fast pace. However, in countries like Slovakia or Poland, the period of negative lending dynamics was very short, while in other countries, such as Hungary, bank lending to the private sector has not yet recovered.

In this paper, we examine the drivers of lending patterns in the Hungarian banking system with special regard on liquidity position. We construct a novel panel dataset for the Hungarian banking system which contains all the important characteristics of the 11 most important Hungarian banks in the period of 1999 – 2013. We will also include parent bank traits to verify the notion that parent groups' position is very dominant in subsidiaries' activities. Finally, crisis effects will be also analyzed. We find clear evidence on the importance of liquidity position in lending activity. Higher loan to deposit ratio hinders lending activity. Other types of liquidity risk (e.g. reliance on FX swap market, stock of liquid assets) also has crucial role in lending. Beside individual bank characteristics funding, capital and profitability position of foreign parent banks has also a strong effect on subsidiary lending. Finally, we find that the crisis changed these relationships to some extent. After 2009, solvency measures became more crucial in lending activity and the significance of liquidity measures decreased somewhat.

Banai et al. (2010b) has analyzed the behavior of Hungarian banks before and in the crisis but accurate empirical research has not been made in their paper. According to their

descriptive analysis before the crisis, the risk-taking appetite of Hungarian banks was very high, which resulted in a lending boom. The Hungarian banking system was characterized by intensive risk-based competition, reflected by several different factors. First, as banks were trying to reach a customer base as broad as possible, they loosened their credit conditions. E.g. LTVs (Loan-to-value) increased significantly between 2004 and 2008 in the household sector. At the same time, FX loans became the most popular products both for the corporate and the household sectors. Parallel to this, significant funding liquidity risks were also built up in the banking sector which hindered lending activity especially during the crisis. Our research can confirm this finding empirically. Our finding that in the crisis capital position became more and more important is also in line with Banai et al. (2010b).

Some empirical research, like that of Sóvágó (2011) examines lending activity in the Hungarian banking system, nevertheless, the relationship of banks' liquidity position and lending activity has not yet been explored. In the international literature papers can be found that pursue a rigorous study of the drivers of bank lending to the private sector. Cornett et al. (2011) examined the behavior of the US banking system. They conducted their research in a relatively early stage of the crisis, but they were able to prove the importance of liquidity positions in lending decisions during the crisis. They found – in-line with our research - that those banks which relied more on stable funding had the opportunity to lend more actively relative to other banks.

A paper by Aydin (2008), written before the crisis, already focused on the drivers of lending activity in the CEE region. This study was based on bank level data in the CEE region and covered 72 banks from 10 countries. The period from the transition until 2007 was observed, meaning crisis effects have not been included. The paper suggests that foreign ownership eased the access to external funding sources which, in turn, supported credit growth. This also suggests that the actual funding position of banks are not important in banking systems with foreign dominance, as banks can easily extend their liquidity sources. To the contrary, our research on the Hungarian banking system suggest that individual funding position is an important driver of bank lending even in a banking system with foreign dominance.

The onset of the crisis changed the landscape of the CEE banking sector significantly. As we mentioned earlier, the lending activity of different countries is characterized by high deviation. Temesváry and Banai (2015) focused on the drivers of lending activity in CEE banking. In line with Everaert et al. (2015), they showed the importance of good portfolio quality and sound solvency positions in terms of lending activity. In addition, they analyzed the effect of parent group traits as well. Findings suggested that lower liquidity of the parent encouraged lending before the crisis, but hindered subsidiary lending during the crisis. Somewhat contradicting Banai et al. (2010a) and Everaert (2015), they emphasize that foreign-owned banks with an unhealthy liquidity position might negatively influence their subsidiaries' activity - in line with Cetorelli and Goldberg (2011). The significant effect of parent traits is also an important finding of our research. Although we emphasize that ownership structure in itself is not important.

These papers offer vital insight on lending activity in the CEE region as a whole, but the very wide panel datasets may mask important individual characteristics. In our paper, we attempt to clarify the picture of the Hungarian banking system.[34] Our results confirm that it is very important to make individual country studies beside region wide researches.

Drivers of bank lending carry particular importance in Hungary for several reasons. First, the capital market of Hungary is underdeveloped. The share of bonds on the corporate sector's liability side was around one per cent in the twenty five years after the transition (Appendix 8.2. chart 1). Only the largest corporations can get funding on the bond market. Since these companies are mostly foreign-owned, other sources are also available to them (e.g. via the banking connections of their parent companies or capital markets of parent companies). Domestic companies are, on the other hand, reliant mostly on the Hungarian banking system. Especially for the SME sector - which has a crucial role in employment – the sound functioning of the banking system is indispensable.

[34] We use a very detailed dataset which make available the estimations only on the Hungarian banking system.

The second reason behind our interest in the drivers of bank lending is the relative position of Hungary in the region in terms of lending dynamics. The main peer countries of Hungary, the so-called V4 countries, are following a very different trend in lending. After the onset of the crisis, they did not have to face a severe drop in lending. Consequently, in their case, the size of the loan portfolio is well above the pre-crisis level. The situation of Bulgaria and Romania can be also considered better from this perspective. Among the regional EU countries, only the Baltic states and Croatia suffer from falling loan portfolios (Appendix 8.1 chart 2). Although the economic performance of Hungary was relatively good in the last two years, the literature suggests that economic recovery without lending might be fragile and slower on a longer horizon (Abiad et al. 2011, Bijsterbosch and Dahlhaus 2011).

The third motivation behind our study is the heterogeneity in lending dynamics of individual banks in the Hungarian banking system. Examining the time series of individual banks' balance sheets, we observe significant differences. At the end of 2013, some banks' loan portfolios exceeded 90 per cent of the pre-crisis level (31 December 2008) and had already started to increase. Other banks are still under a severe adjustment process and their loan portfolio almost halved in a 5 year period (Appendix 8.1 Chart 3.). We think that these differences might be explained by structural differences.

The paper proceeds as follows. Section 5.2 presents the econometric framework and discusses the empirical strategy. Section 5.3 describes the data sources in detail. Section 5.4 discusses the results of the estimation. Section 5.5 concludes.

5.2 Methodology

The dependent variable is the annual credit growth, defined as the annual percentage change of the loan stock to household and corporate sector. Let L_t^j denote the exchange-rate

adjusted volume of lending[35] by bank j at time t (where t denotes the quarter). Then the dependent variable l_t^j is the annual flow of lending, defined as follows:

$$(1) \quad l_t^j = [\ln L_t^j - \ln L_{t-4}^j] * 100$$

$$(2) \quad l_t^j = \alpha_1 + \alpha_2 Y_{t-4}^j + \alpha_3 X_t^j + \varepsilon_t^j$$

Equation 2 defines our basic empirical specification. As mentioned before the dependent variable is the exchange-rate adjusted percentage change of loan stock. Y_{t-4}^j is the set of bank characteristics. The (t - 4) formulation comes from the fact that the dependent variable is the annual (four quarter) change in the stock of claims and the dataset is with quarterly frequency. Since our main focus is the effect of liquidity, we are applying more liquidity measures to cover different forms of liquidity risk. This idea is in line with the direction of global regulatory steps, such as the liquidity rules in Basel III (BIS 2013, BIS 2014). *Loan to deposit ratio* is a widely used measure of funding structure. We expect that, on a longer horizon, it will have a negative effect on lending activity. Stable funding sources, such as internal deposit savings, are important for sound banking. *Liquid asset to total asset ratio* focuses more on short term shock absorbing capacity. Contrary to the former, our expectation on the sign of the coefficient is ambivalent. A higher liquidity buffer means a better ability for prudent lending but at the same time usually more cautious banks tend to keep higher liquidity buffer. Finally, we also include *net FX swap stock to total asset* as a liquidity measure. Although only a small part of the banks in the sample had a high reliance on the FX swap market, it might have an important effect on lending. FX swap does not only decrease the liquidity buffer, but it also has a high roll-over risk as most transactions are very short (Banai et al. 2013). During the crisis, this market underwent significant turmoil, supporting the idea that a relatively high stock of FX swaps might have a negative effect on lending. Beside liquidity measures, other important variables are also applied. *Non-performing loan ratio* is widely used for controlling for portfolio quality. Temesváry

[35] Exchange rate movements in Hungary has a significant effect on the stock of the loan portfolio since FX loans are dominant in the balance sheet of banks. For this reason we used 2013 year end data as an 'exchange rate deflator' and reevaluted the stock.

and Banai (2015) or Everaert et al. (2015) have shown that problems with portfolio quality result in lower lending activity. Therefore, we again expect a negative sign. Capitalization – measured by *capital adequacy ratio* – might have a significant effect on lending as well. However, its sign depends significantly on external factors (e.g. parent bank's capital management, operation of supervisory authority). For example, it is shown by Ongena et al. (2014) that low-capitalized banks tend to lend more actively in foreign currency. Finally, bank size is measured as the log of the subsidiary's lagged total assets. We expect a negative sign which has a technical reason. The same amount of net lending for a smaller bank means a higher pace of growth. The vector X^j contains the set of controls such as: *merger dummy* for M&A activity; *transition dummy* for the first three years of the sample period; a control for *crisis* time; a *parent dummy* which controls for the effect of foreign ownership and a control for the government's *early repayment scheme*[36] which caused a negative downward shift at the household loan portfolio.

$$(3) \quad l_t^j = \gamma_1 + \gamma_2 Y_{t-4}^j + \gamma_3 X_t^j + \gamma_5 M_t + \varepsilon_t^j$$

The second specification (Equation 3) is an expanded version of the previous. It now includes macro variables to control for demand-side effects. The vector of macro controls '*M*' includes: *annual nominal GDP growth* to capture the economic performance of the country, *EUR/HUF* which contains information on the country's riskiness, *3 month BUBOR* as the price of loans and the *consumer sentiment index*. All the models are also estimated with time fixed effects (contained by X^j) instead of using macro variables to control for the demand side.

$$(4) \quad l_t^j = \gamma_1 + \gamma_2 Y_{t-4}^j + \gamma_3 Y_{t-4}^{j,g} + \gamma_4 X_t^j + \gamma_5 M_t + \varepsilon_t^{j,g}$$

In Equation 4 parent group characteristics are taken into account. It must be emphasized that this specification is tested on a smaller sample for two reasons: (1) obviously domestic banks are left out since they have no parent institution, (2) only shorter time series are

[36] „In order to reduce the vulnerability stemming from the high foreign exchange exposure of households, the government made early repayment at a preferential fixed exchange rate possible for foreign currency denominated mortgage loan debtors." (MNB 2012)

publicly available for some foreign groups. $Y_{t-4}^{j,g}$ contains parent group characteristics, i.e. *leverage ratio, NPL ratio, capital adequacy ratio and return on assets.* Finally, we also analyzed the effects of the crisis. Equation 5 incorporates interactions between the crisis dummy and bank-specific and macro variables.

$$(5) \quad l_t^j = \delta_1 \ + C_t \ \times [\delta_2 \ Y_{t-4}^j + \delta_3 \ X_t^{j,g} + \delta_4 \ M_t \ ] + \varepsilon_t^c$$

5.3 Data description

We have constructed a quarterly panel dataset which includes data of 11 banks[37] operating in Hungary between 1998 Q4[38] and 2013 Q4. We only selected banks which were present during the entirety of the observation period and which are relevant on the Hungarian market. Niche banks with small share on the Hungarian market are excluded. Bank subsidiaries operating in Hungary are consolidated. We decided not to include the year 2014 because the compensation of household FX borrowers had a significant one-off effect.

The bank-specific characteristics in Y^j are as follows. *Loan to deposit ratio* is defined as total loan to non-financial private sector to total deposit from non-financial private sector, times 100. *FX swap to total asset ratio* is defined as net stock of FX swap transactions against HUF to total asset, times 100. *Liquid asset to total asset ratio* is defined as the sum of liquid assets – contains cash and cash equivalents, government securities, central bank bills and deposits – to total assets, times 100. *SREP capital ratio* is the capital adequacy ratio of each banks taking into account the supervisory review and evaluation process from 2008. Pillar 2 processes may result in large differences between capital requirements, consequently we find it important to consider them. *NPL ratio* is the non-performing loan stock by classification categories (the sum of the three worst categories i.e. substandard, doubtful and bad) to total loan stock, times 100. Although 90 days overdue loans are used most frequently as a definition of non-performance, we have chosen the classification-

[37] Namely, OTP Bank, FHB Bank, CIB Bank, Unicredit Bank, Raiffeisen Bank, Erste Bank, K&H bank, MKB Bank, Budapest Bank, Commerzbank and Volksbank. Although, more than 30 banks are left out but these 11 banks have circa 90 per cent market share through the whole observation period.

[38] Since we use explanatory variables with 4 lags the estimations were made for the period 1999Q4 and 2013 Q4.

based data, as it affords us a longer time series. The *Total Assets* variable is defined as the log of the lagged total assets of the subsidiary. All of this bank-specific data is from the database of the Magyar Nemzeti Bank.

The parent group specific covariates in $Y^{j,g}$ are defined as follows. *Loan to deposit ratio* is - similar to subsidiary characteristics – total loans to total deposit at the group level. *Capital adequacy ratio* on a group level contrary to the one applied on a subsidiary level doesn't contain information on Pillar 2 processes, only the official data. *Leverage ratio* is defined as total assets to capital, thus, in this case, a higher number implies higher risk. Finally, *ROA* is defined as profit after tax to total assets. Parent group information is collected from Bankscope and the annual reports of these banks. Budapest Bank is excluded from the specifications of foreign-owned banks due to the special characteristics of the owner group GE.

The vector of macro characteristics *M* for Hungary controls for demand-side factors. It contains the following measures. The annual *GDP growth* rate is defined as the annual change of nominal[39] gross domestic product. The *HUF/EUR* exchange rate is also applied among macro factors. The *3 months BUBOR* interest rate is defined as an annual average of the interbank offered rate.[40] Finally, a *Consumer sentiment indicator* is also applied. Data source of the HUF/EUR and the BUBOR is the Magyar Nemzeti Bank. In case of GDP KSH (Hungarian Central Statistical Office) statistics are used. The sentiment indicator is from the Eurostat.

Several different dummies are also included in our specifications. These controls in are as follows. A dummy for the period of *transition* is applied to control for any specificity of the first three years of our sample (until 2002). For the *crisis* period from 2009 until 2013, another dummy is included to capture the regime change of lending policy which characterizes the whole banking system (Everaert et al., 2015). As we mentioned in the

[39] Nominal number is applied since we are explaining annual nominal change of loan stock.

[40] E.g. in 2010 Q3 the average of 2009 Q4, 2010 Q1, 2010 Q2 and 2010 Q3 is applied. Since we don't use any lag in case of this variable these are the actual interest rate conditions the customer have to face with during any observed period.

introduction, several papers found significant differences in lending activity between foreign-owned and domestic banks. To control for this, a *parent dummy* is applied. During the sample period, several bank mergers[41] took place in Hungary that affected the growth of loan stock at these banks, supporting the inclusion of a *merger dummy*. Due to the *early repayment* scheme, which had a significant negative effect on the size of the loan portfolio, we control for that particular period as well. Finally, time fixed effects are also applied in some specifications controlling for the demand side.[42]

Other frequently used bank characteristics, such as profitability ratios (e.g. ROA, ROE) or funding structure traits (e.g. household deposit to total asset, foreign funds to total assets) were left out due to their high correlation with other measures. Similarly, macro variables, such as unemployment or long-term rates were also left out. We wanted to apply SLO (Senior Loan Officer Survey) data as well to control for demand, but quarterly data is only available on a shorter horizon and for 7 banks.

5.4 Discussion of the results

Tables 1 through 6 in Appendix 8.4 summarize the results of our estimation. First, we discuss the role of bank characteristics (Table 4) including controls for demand (Table 5). Second, foreign parent group characteristics are applied for banks in foreign ownership (Table 6 and 7).[43] In this case, a smaller sample is used as domestic banks and Budapest Bank must be excluded. Finally, Table 9 shows our results on crisis effects.

5.4.1 The role of bank characteristics

Our results strongly confirm the hypothesis that higher funding risk has a significant negative effect on lending activity of banks. *Loan to deposit ratio* (as a measure of funding risk) has a significant negative effect on loan growth. The size of this effect is also economically relevant. A one percentage point higher loan to deposit ratio at a bank might

[41] I.e. merger of CIB and IEB, FHB and Allianz, Erste and Posta Bank

[42] Descriptive statistics and correlation matrix are in Appendix 8.3.

[43] Newey-West estimator is also applied for the main specifications to control for autocorrelation up to four lags (Table 5). The significance levels does not change substantially which also con-firms our former results.

result in 0.08 percentage point lower loan growth. Considering that the loan to deposit ratio is usually well above 100 per cent in the Hungarian banking system (in this sample the mean is 133) and that the mean of loan growth is 18.8 per cent, this is a sizeable effect. This result also suggests that internal savings might be important even in banking systems with foreign dominance. It might imply that easy access to foreign liabilities in itself does not result higher lending activity, conflicting to certain extent with the view described by Aydin (2008). On the other hand, their sample covers a different time period and includes many other countries.

Liquid assets to total assets ratio also has a strong significant effect on our dependent variable and the sign is negative in every specification. It implies that this measure might contain information on risk taking willingness. The size of the coefficient varies between 0.23 and 0.26, which is significant taking into account the mean value of the variable (17.28). Nevertheless, this effect is much lower than that of the loan to deposit ratio. A technical explanation for this result is that the cross-sectional variance in this measure is relatively low. Before the crisis, due to intensive lending by the whole sector, every bank reduced their liquidity buffer (as Banai et al. 2010b showed) and built it back during the crisis period.

The potential effect of *FX swap* stock was also tested because high liquidity risk may stem from high reliance on the FX swap market. Our results are not too strong in this case, as the effect was not significant in all specifications. However, the negative sign confirms our assumption: higher reliance on FX swaps hinders lending.

Our results suggest that the size of the bank has a significant negative effect on lending. This result is in line with the findings of other papers (Aydin 2008, Everaert et al. 2015, Temesváry and Banai 2015). It may have a technical explanation. The same nominal amount of net issuance for a smaller bank results in a higher growth pace. During the sample period, the size of the banks changed radically. At the early stages, the banking system was just after the transition, i.e. they had just launched their operation. As our

sample contains the most relevant Hungarian banks, it is not surprising that there is no significant difference between them in terms of market power[44].

The onset of the *crisis* changed the lending policy of Hungarian banks significantly. The systemic data has also shown a radical negative downward shift in lending dynamics and our model confirms this. Not surprisingly, the coefficient on the crisis dummy is negative and significant both economically and statistically, which is in line with the relevant literature (De Haas et al. 2012, Temesváry and Banai 2015, Everaert et al. 2015). Our model does not confirm the view that ownership structure has a significant effect on lending activity. The existence of a foreign parent bank has no significant effect on lending. The literature is ambiguous on this topic as some papers (e.g. Banai et al. 2010a) emphasize the support and commitment of foreign parent banks, while others underline the potential contagious effect of foreign ownership (De Haas et al. 2012). Our results suggest that the ownership structure itself does not distinguish between the lending activities of banks. Of course a limitation of our estimation is that there are only two relevant domestic players in the Hungarian banking system.

5.4.2 The role of parent group characteristics

As a step forward, we also investigate the potential role of foreign parent banks in the activities of their Hungarian subsidiary (Table 3 and 4). We have seen that ownership is not a relevant explanatory variable of lending dynamics. Our main question is then whether characteristics of parent banking groups can explain the difference between the lending policies of their local subsidiaries. As Equation 4 shows, the former specification is expanded with important parent characteristics such as ROA, NPL, CAR and leverage.

Our first finding is that parent banks' funding liquidity risk has a significant negative effect on subsidiaries' lending. Although the coefficient is significant, its value is only a fourth of the coefficient of local banks' *loan to deposit ratio*. However, Hungarian banks belonging to groups with better liquidity positions tend to lend more actively than their competitors with riskier owners. This idea somewhat supports the views of Cetorelli and Goldberg

[44] In this sense the only outlier is OTP.

(2011) or Giannetti and Laeven (2012) in the sense that parents' liquidity problems may negatively affect the lending activity of their Hungarian subsidiaries. Nevertheless, it is important to emphasize that this does not mean an abrupt withdrawal of funds during crisis time, but rather a more intensive adjustment on the lending side.

We also find a significant relationship between capitalization of parent groups and the lending of their Hungarian subsidiaries. One percentage point lower leverage ratio at the parent group means 1.4 percentage point higher loan growth at local banks. This result is not surprising. Well-capitalized banks had the chance, even in crisis time, to support the activity of their Hungarian subsidiary. Finally, the profitability of parent groups also boosts lending activity at their local banks. This finding is in line with expectations. On the one hand, higher profitability strengthens the ability of banks to lend more. On the other hand, it also implies a higher potential return in the future, which also motivates further lending activity.

Next, we re-estimated the effect of individual bank characteristics on this narrower sample with the inclusion of parent group characteristics and demand controls. This step confirmed our former results. The effect of liquidity measures and balance sheet size is significant again with the same sign and similar size as before. One relevant difference is that capital adequacy has a significant negative effect in one specification. This surprising finding might be explained by the fact that the capital management policies of foreign-owned banks are very different. Some of them hold capital adequacy ratio on the level of regulatory minimum, while others keep a sizeable buffer no matter what their future business plans are. From this perspective, CAR may not be an important factor in lending decisions (Temesváry, 2014b).[45]

5.4.3 Crisis effects

As many authors have already discussed, the financial crisis hit the region hard,, changing the landscape of bank lending (e.g. De Haas et al. 2012, Sóvágó 2011, Banai et al. 2010a,

[45] Newey-West estimator is also applied for the main specifications to control for autocorrela-tion up to four lags (Table 5). The significance levels does not change substantially which also confirms our former results.

Fábián et al. 2010). Papers (e.g. Temesváry 2014) suggest that after the crisis, not only did the loan stock shrink, but the way in which bank characteristics affected lending policy also changed. We analyze the effect of the crisis by interacting our former explanatory variables with the crisis dummy. We summarize the results in Table 6.[46]

In our estimation on the full fifteen year-long sample, it was surprising to find that the size of the *liquid asset buffer* affects lending dynamics negatively. This may be due to the fact that this variable may contain information on risk-taking willingness. The interaction with the crisis dummy supports this view since the negative and significant coefficient corresponds only to the pre-crisis period. After 2009, this measure no longer has any impact on lending policy. Contrary to this, funding liquidity risk has a negative effect both before and during the crisis, although the absolute size of the coefficient and its significance level decreased in the last couple of years. While before the crisis, a one percentage point higher *loan to deposit ratio* resulted in 0.1 percentage point lower loan growth, this rate is only 0.04 for the period between 2009 and 2013. This implies that although abrupt policy steps were needed due to liquidity problems after the Lehman collapse, liquidity position is not the most important factor explaining differences in lending behaviors after the onset of the crisis.

Solvency measures were not significant in any of the specifications for the full sample. Our examination of the crisis effects somewhat alters this view. *NPL ratio* has a positive effect on lending before the crisis but has a negative sign after 2009. The former may have two explanations: 1) similar to the liquidity buffer, NPL ratio might also contain information on risk taking and 2) NPL ratios were not very high before the crisis – the mean was 3.6 – so it was not a big burden on any of the banks. The post-Lehman result of a negative coefficient meets our expectations, as earlier literature (e.g. Evereart et al. 2015) also suggests that impaired assets hinder bank lending. It should be noted, however, that this result is not significant for all the specifications we ran for the crisis period. In line with the finding on the effect of NPL, capital adequacy ratio has a significant positive impact on lending. An

[46] This examination is made on the full sample only since the size of the subsample for foreign-owned banks may decrease the robustness of the results.

increase in *capital adequacy ratio after the SREP* by one percentage point increased lending growth by a range of 0.29 to 0.41 percentage points during the crisis. These results imply that during the whole 5 years of the post-Lehman period, solvency position of banks is a more important determinant of lending activity than liquidity position. However, it is possible that immediately after the onset of the crisis, sudden liquidity need became the most important factor driving lending activity, as found by Banai et al. (2010b).

The effect of ownership is also tested for the two different periods, but we don't find significant results in either sub-sample. Finally, in line with our expectations, size has a negative effect on lending. Bank size has a technical effect in that the same nominal issuance for a smaller bank corresponds to a higher growth rate. Other papers like (Temesváry and Banai 2015 or Everaert et al. 2015) found the same result.

Macro variables do not have consistently significant effects on lending in our specifications on the whole sample. The distinction between the crisis and non-crisis periods changes this picture. GDP growth has a significant positive impact on lending after 2008. One percentage point higher growth has a positive impact on lending growth, increasing it by 1.1 percentage points. 3 months BUBOR also has a positive impact on lending dynamics in the crisis. Although seemingly opposed to economic intuition, this can be explained by the fact that at the early stages of the crisis, the rate was kept high for financial stability reasons, but bank loans began decreasing drastically only from the end of 2009. From 2010 to 2013, loans to the private sector decreased steadily, independently from interest rate movements. The significance of macro factors during the crisis, parallel with the decreasing significance of bank characteristics, suggests that demand-side factors become more important during the crisis and the relevance of the supply side diminished (contrary to Everaert et al. 2015). Nevertheless, this idea has to be tested empirically.

5.5 Conclusions

In this paper, we examined the determinants of lending dynamics in the Hungarian banking system. We have constructed a database which contains all the relevant characteristics of the most important Hungarian banks between 1998 and 2013. Our dataset also contained some balance sheet traits of foreign parent groups. Using this data, we were able to identify the relative importance of bank and parent bank characteristics and demand-side factors.

Although several papers have already analyzed lending activity of the Hungarian banking system, this is the first paper to examine it on micro data.

We found that during the observed one and a half decade, banks that were able to rely more on internal savings tended to lend more actively. The positive effect of better liquidity position on lending activity is also supported by another finding, which implies that higher reliance on the FX swap market hinders lending. Although many papers suggest that foreign-owned banks and domestic banks behave differently, our results on the Hungarian market did not support this notion. We have found the existence of a foreign owner to be insignificant in terms of lending activity. Nevertheless, parent group traits had significant explanatory power on foreign-owned banks' loan growth. Banks which had a better capitalized, more profitable parent group with safer funding liquidity position tended to lend more.

The effect of the crisis was also examined. We found that from 2009, the importance of liquidity position has decreased significantly and solvency measures entered the spotlight. This result gives empirical proof to the idea set forth by Banai et al. (2010a). Our estimations showed that during the crisis, the explanatory power of individual bank characteristics weakened while macro factors gained relevance. This result suggests that demand-side factors became more dominant than the supply side during the crisis. An interesting extension of this paper would be to put this observation to further empirical testing.

6. THE DRIVERS OF FOREIGN BANK LENDING IN CENTRAL AND EASTERN EUROPE: THE ROLES OF PARENT, SUBSIDIARY AND HOST MARKET TRAITS[47]

We analyze the relative roles of subsidiary and parent banking group traits in driving foreign banks' lending patterns in the Central and Eastern European (CEE) region before and during the crisis. We use a new bank-level dataset on Western European banking groups and their CEE subsidiaries over the 2002-2013 period. We find that a bank's non-performing loans (NPL) ratio significantly lowered lending growth, while the parent bank's profitability encouraged subsidiary lending before the crisis. During the crisis, high bank NPLs and lower parent funding liquidity hindered lending, while better capitalization encouraged lending growth. Results suggest purging banks of NPLs, enhanced regulatory coordination and the inclusion of parent bank traits in countercyclical capital buffer calculations.

Keywords: Bank lending flows; Foreign banks; Financial crises; Bank-level data; Cross-country analysis

JEL codes*:* F42; G21; G28

[47] Joint work with Judit Temesváry. The paper is under review at Journal of International Money and Finance

6.1 Introduction

The goal of this paper is to examine the drivers of the lending patterns of foreign banks[48] in the Central and Eastern European (CEE) region over the past decade. The analysis relies on a newly compiled dataset that contains detailed balance sheet and financial performance information on Western European banking groups and their CEE subsidiaries, with annual frequency over the 2002-2013 period. Our main contributions are the parallel analysis of the relative roles of subsidiary and parent banking group traits in driving foreign bank lending, and the study of how these relationships have changed since the onset of the financial crisis relative to the pre-crisis period. Our paper adds to the literature by extending the analysis through 2013 to study how the financial crisis may have altered parent groups' role in subsidiary lending. The crisis has affected bank lending in the CEE countries since its onset in 2008-2009. Our newly compiled dataset also contains a broad set of bank performance indicators (i.e. profitability, funding risk, credit portfolio and capitalization) both for subsidiaries and their parent companies. Furthermore, our new dataset also allows us to better identify common regional patterns since it covers CEE countries whose banking systems are more homogenous in their evolution and structure than those in previous CEE-focused studies (e.g. Popov and Udell (2012) and De Haas and van Lelyveld (2010)).

We examine four hypotheses related to the functioning of foreign banks in the CEE region. First, in line with recent policy initiatives we hypothesize that high non-performing loan ratios on banks' books significantly hinder lending activity. Indeed, we find strong evidence that a bank's non-performing loans (NPL) ratio forms a significant obstacle to lending growth, a result which prevails in the crisis period as well. Second, we examine the hypothesis that better capitalization provided substantial support to CEE subsidiaries in their lending activities after the onset of the crisis, while capital played a less important role before the crisis. We see a very strong and sizable positive relationship between the subsidiary's capitalization and lending activity during the crisis period. This result is in line with Popov and Udell (2012) and Frey and Kerl (2015)'s findings, but our study goes further in that we extend the analysis to lending to the whole non-financial sector and we

[48] We refer to "foreign banks" as those banks with strategic foreign owners.

examine a longer time horizon including the crisis years. Our third hypothesis is that the financial and real economic benefits that foreign banks can bring to emerging financial markets depend on the health and characteristics of the parent banking groups. Motivated by Popov and Udell (2012) and De Haas and van Lelyveld (2010) who find that parent balance sheet effects can play an important role in subsidiary lending, we include a set of parent banking group traits as covariates. We find that the parent group's profitability (as measured by Return on Assets) encourages subsidiary lending before the crisis. Our third hypothesis is supported by our finding that lower funding liquidity of the parent encouraged lending before the crisis, but hindered subsidiary lending during the crisis. This result is also in line with Cetorelli and Goldberg (2011), who study U.S. banks' lending abroad to show that parent banks channel funds to and from subsidiaries via internal capital markets as their liquidity position changes. These results are also consistent with the findings of Giannetti and Laeven (2012) and De Haas and van Lelyveld (2006), who find that parent banks tend to withdraw funds from subsidiaries abroad during crisis times.

Our fourth and last hypothesis is that the collective commitment that parent banks made in the context of the Vienna Initiative not only stabilized the liquidity position of CEE subsidiaries (Banai et al. 2010), but also helped mitigate the crisis effect on their lending. To the contrary, we find a very strong and negative crisis effect on CEE lending, despite the Vienna Initiative. This result is in line with the finding of De Haas et al (2015) and Cull and Martinez Pereira (2013), who show that the subsidiaries of foreign banks reduced their lending early and quickly after the crisis hit. Based on De Haas and van Lelyveld (2014), the joint implication of the negative parent balance sheet effects and the quick reduction of subsidiary lending in the crisis is that parent banks did not provide sufficient support to their CEE subsidiaries during the crisis, leading to a substantial reduction in lending activity in these host markets.

6.1.1 Some important features of current-day banking in the CEE region

The list of countries and banks covered in the analysis is included in Appendix 8.8. Appendix 8.9 contains a detailed discussion of the historical evolution of banking in the CEE countries. The analysis in this paper builds on three important features of banking in the CEE region. First, we study bank lending because the banking sector is of fundamental

importance in financing economic activity in the CEE region. Countries in the CEE region are characterized by under-developed capital markets, which implies that investors and firms can only have access to external funding through the banking system. Studying the aggregate balance sheet of the corporate sector reveals similar features in all CEE countries: equity and bank loans cover almost the entire liability side, while the role of securities is marginal. The strong prevalence of bank financing holds up in the cross-section and over time as well: only one to five percent of liabilities comes from capital markets (Appendix 8.5 Table 2). Moreover, the limited amount of funds from capital markets generally go to the largest companies.[49]

Second, we focus exclusively on the lending activity of the subsidiaries of foreign banking groups, as these foreign banks overwhelmingly dominate the CEE financial markets. While the internationalization of banking has been a common phenomenon since the mid-1990s (Claessens and van Horen, 2014), the rapid pace of foreign bank entry and market build-up in the CEE region is particularly striking. As discussed in Appendix 8.9 in detail, the evolution of the banking systems in the CEE region followed similar patterns across countries. Specifically, the consolidation and privatization processes in the aftermath of the collapse of the Soviet Union invariably led to the dominance of foreign banking groups (Berger, 2007). By the onset of the financial crisis in 2008, at least two-thirds of the total assets of these banking systems was in foreign ownership. In some cases this ratio reached above 90 percent. [50] This ownership structure remained effectively unchanged throughout the crisis period. The ownership shares in 2011 are almost the same as those in 2008, as shown by Appendix 8.5 Table 1.

Third, we rely on cross-country variation in bank-level lending to identify the primary drivers of bank lending. While fast growth of the stock of loans characterized most of the region until the end of 2008, starting with the onset of the real economic effects of the

[49] Intra-company lending (an alternative to bank financing) is an option that is generally only available to bigger, foreign-owned companies.

[50]Such high rates of foreign bank ownership are worrisome in light of the finding by Lee and Hsieh (2014) that financial stability and foreign bank ownership show an inverse U-shaped relationship. Wu et al (2011) show that high foreign bank ownership significantly reduces the bank lending channel of monetary policy.

financial crisis in 2009 the CEE countries began to show very different patterns in bank lending activity. In some countries, such as Poland and Slovakia, the growth of credit to the private sector continued (although at a much slower pace). In others, such as Hungary and Latvia, the current size of the loan portfolio is far below its former peak in 2008 (Appendix 8.5 Figure 1). The substantial cross-country differences in Appendix 8.5 Figure 1 can be surprising, as countries in the CEE region are generally considered homogenous by foreign investors. In this paper, we shed light on the importance of these cross-country differences by considering the relative roles of subsidiary, banking group and host country macro traits in driving foreign banks' CEE lending.

The paper proceeds as follows. Section 6.2 presents the econometric framework and discusses the empirical strategy. Section 6.3 describes the data sources in detail. Section 6.4 discusses the results of the estimation. Section 6.5 concludes. All tables are compiled at the end of the text.

6.1.2 Empirical Hypotheses

In our paper we focus on the following four hypotheses:

1. *High non-performing loan ratios (NPL) negatively affected the amount of lending in the CEE region*. A high NPL ratio on the bank's balance sheet implies substantial risks on the liquidity and solvency side as well. In addition to the potential losses, high NPLs necessitate additional funding and capital needs, which prohibit lending activity. Management of NPLs also complicates the allocation of resources (e.g. human resources) which makes operation more expensive. Finally, the presence of a high NPL generally translates into increased caution in bank behavior. Due to these factors, the worsening of the portfolio quality can be a huge burden for the banking system and hinders lending activity. Based on prior crisis experiences, the reduction of NPL ratios in the CEE region became an important policy focus for supranational institutions. As part of the so-called Vienna Initiative, a joint working group was established by the EBRD, IMF, EC, EIB, World Bank and the ECB with a focus on managing high NPL ratios (Vienna Initiative, 2012). Due to the recently renewed policy relevance of high NPLs, we find it important to analyze their economic effects on lending activity.

2. *The capitalization of CEE subsidiaries has become substantially more important since the onset of the financial crisis*. Before the crisis, the capitalization of subsidiaries played an insignificant role in ensuring their liquidity, since parent funding guaranteed a certain capital position. After the onset of the crisis, however, the relative role of local capital conditions became important rather than parent bank capitalization. Both the CEE region's and the parent banks' home countries' banking sectors suffered huge losses in the crisis, making internal capital accumulation impossible. In addition, both investors and regulators expected increasingly higher capital adequacy ratios (CAR). These factors led parent banking groups to make significant adjustments, which might hinder them in providing capital to their subsidiaries to support their lending.

3. *The balance sheet conditions of parent banks have an important role in shaping the activities of their CEE subsidiaries*. There is evidence that Western banks transfer banking know-how into less financially developed regions through their subsidiaries, and especially so during the evolution of the host country banking systems (Goldberg, 2007). In particular, Havrylchyk and Jurzyk (2011) show that subsidiaries in Eastern Europe which are acquired by foreign banks are more cost-efficient and profitable than their local counterparts. In this context, understanding the strength of the relationship between parent banks and their subsidiaries can shed further light on the positive externalities afforded by foreign banks. We hypothesize that parent banks have an important role in shaping their subsidiaries' activities in the CEE region. Anecdotal evidence suggests that parent banks have strong control over their subsidiaries, and their strategy is to focus on the banking group as a whole unit rather than on individual subsidiaries. These factors imply that parent group characteristics, such as their capital and liquidity position, portfolio quality or profitability, may have significant effects on their subsidiaries' activities.

4. *The Vienna Initiative helped maintain the amount of lending in the CEE region, following parent banks' commitment not to withdraw funds.* The key goal of the joint program of several supranational institutions and the important market participants active in the CEE region was to safeguard the financial stability of emerging Europe. As a first step, banks committed to maintain their pre-crisis exposure. This support

ensured the stable operation of foreign-owned banks in the region, and also helped to stabilize financial markets (Banai et al., 2010). There has been limited work on whether this commitment was sufficient to ensure foreign-owned banks' continued lending, and the support that this lending brought to the real economy.

6.2 Econometric Specification

In our econometric specifications, the dependent variable of interest is the annual flow of lending, defined as the annual percentage change in the stock of lending for the given bank-country-year combination. Let $L_{i,t}^{j}$ denote the exchange rate-adjusted volume of lending by bank j to country i at time t (where t denotes the year). Then the dependent variable $l_{i,t}^{j}$ is the annual *flow* of lending, defined as:[51]

$$(1) \quad l_{i,t}^{j} = [\ln L_{i,t}^{j} - \ln L_{i,t-1}^{j}] * 100$$

Each year, banks convert the foreign currency (FX)-denominated loans into local currency units (LCU) at contemporaneous exchange rates, so that they can report total loan volumes in LCU's. Therefore, an important issue to tackle is the impact of exchange rate movements on the evolution of the stock of loan volumes over time. We adjust for exchange rate movements according to the following convention. First, using data on the share of FX loans in total loans, we calculate the volume of total lending that has been subject to exchange rate movements.[52] Second, we convert this amount into 2013 LCU's using 2013 as the base year (i.e. with 2013 exchange rates, using an exchange rate deflator). This normalized stock of loans is what we call L in Equation (1) above. The basic empirical specification takes the following form:

$$(2) \quad l_{i,t}^{j} = \alpha_1 + \alpha_2 Y_{i,t-1}^{j} + \alpha_3 X_{i,t}^{j} + \varepsilon_{i,t}^{j}$$

[51] It is our understanding that portfolio cleaning by sell-offs or write-offs is not common practice among CEE banks. Therefore, we do not explicitly consider the potential distorting effects that these practices could have on lending flows.

[52] Exchange rate adjustment of nominal volumes is important because of the high prevalence of foreign currency-based lending in the CEE region during our sample. In the absence of such adjustments, exchange rate movements may distort the estimation results by causing substantial changes in the nominal value of the loan stock.

In Equation (2), $Y_{i,t-1}^{j}$ is the set of subsidiary balance sheet characteristics, containing the following variables: the *Loan to Deposit Ratio* is a lagged measure of the subsidiary's funding liquidity[53] conditions, *Returns on Assets* is a lagged measure of the subsidiary's profitability, the *Leverage Ratio* is a lagged measure of capitalization, the *Non-performing Loans* is a lagged measure of portfolio quality and *Total Assets* is the log of the subsidiary's lagged total assets. The vector X^{j} contains the set of controls such as: a *Merger* dummy to indicate the subsidiary's M&A activity, and the *Crisis* indicator to capture the onset of the financial crisis. A set of banking group, subsidiary and host country fixed effects are included to control for country and time-specific changes in and shocks to credit demand.

Equation (3) is an expanded version of the previous specification, now including a set of parent banking group balance sheet characteristics.

$$(3) \quad l_{i,t}^{j} = \beta_1 + \beta_2\, Y_{i,t-1}^{j} + \beta_3\, Y_{t-1}^{j,g} + \beta_4\, X_{i,t}^{j,g} + \varepsilon_{i,t}^{j,g}$$

Where in addition to the subsidiary characteristics, the set of variables in $Y_{t-1}^{j,g}$ contain the parent banking group equivalents of the subsidiary traits described immediately above. The set of controls in $X^{j,g}$ contains banking group, subsidiary and host country fixed effects and indicators for parent M&A activity and the crisis period. Our third specification adds a set of host country macro effects as well:

$$(4) \quad l_{i,t}^{j} = \gamma_1 + \gamma_2\, Y_{i,t-1}^{j} + \gamma_3\, Y_{t-1}^{j,g} + \gamma_4\, X_{i,t}^{j,g} + \gamma_5\, H_{i,t-1} + \varepsilon_{i,h,t}^{j,g}$$

Where the set of host country macro controls includes: the lagged *Public Debt to GDP* ratio of the host country, the annual *GDP Growth* rate of the host country, the annual *CPI Inflation* rate, and the *Net External Debt to GDP* ratio. We include host country macro controls for two reasons. First, the inclusion of these macro-level measures of economic performance enables us to better control for aggregate factors that may impact the expected profitability of lending in a given country. Second, they also help capture unobservable country-level shocks that may impact the demand for bank credit over time.

[53] For the majority of banks, we do not have data on the proportion of high quality liquid assets.

Our last, and most complete, specification incorporates interactions between the subsidiary, parent banking group and host country covariates and the financial *Crisis* dummy[54]:

$$(5) \quad l_{i,t}^{j} = \delta_1 \ + C_t \ \times [\delta_2 \ Y_{i,t-1}^{j} + \delta_3 \ Y_{t-1}^{j,g} + \delta_4 \ X_{i,t}^{j,g} + \delta_5 \ H_{i,t-1}] + \varepsilon_{i,h,t}^{c}$$

In Equation (5), C_t is the financial crisis dummy variable. The goal of the empirical estimation below is to obtain estimates of the coefficient vectors (α; β; γ; δ).

6.3 Data Description

The subsidiary-specific balance sheet covariates in Y_i^j are defined as follows. The *Loan to Deposit Ratio* is defined as the stock of *Total Loans* divided by the stock of *Total Deposits*, times 100. *Returns on Assets* captures profitability, and is defined as *Net Returns* over *Total Assets*, times 100. The *Leverage Ratio* is included as a measure of capitalization, and is defined as *Total Equity* divided by *Total Assets*, times 100. *Non-performing Loans*[55] is each bank subsidiary's ratio of *Non-performing Loans* to *Total Loans*, times 100. The *Total Assets* variables is defined as the log of the lagged total assets of the subsidiary. Data for these bank-specific covariates are collected from Bankscope and annual reports from individual banks' websites. The parent banking group-specific covariates in $Y^{j,g}$ are defined as their subsidiary-level equivalents. Data for these bank-specific covariates are collected from Bankscope and Annual Reports and Financial Statements from individual banks' websites.

The vector of host country macro traits H_i includes the following variables. *Long-term Bond Yield* is included as a measure of country risk.[56] The annual *GDP growth* rate, measured as the annual percentage change in real *Gross Domestic Product*, is a standard measure of economic activity. The annual *CPI Inflation* is the annual percent change in the host country's Consumer Price Index. The *Public Debt to GDP* ratio, which measures the

[54] The implication is that in this specification, the coefficients of the model's variables are estimated for the pre-crisis and the crisis periods separately and simultaneously.

[55] We define NPL as loans which are 90 days overdue, so as to ensure the best compatibility across the sample countries.

[56] We use the long-term bond yield instead of the CDS spread because CDS markets are characteristically under-developed in the CEE region – especially so during the first half of our sample period.

public sector's overall indebtedness, is an indicator of sovereign risk. Similarly, the *Net External Debt to GDP* ratio measures the country's indebtedness to the rest of the world. Data on these variables are collected from the Economist Intelligence Unit's Country Database.

The controls in $X^{j,g}$ are as follows. The variable *Merger* is defined to take on a value of 1 if the subsidiary has engaged in any M&A activity in the previous period, and 0 otherwise. This dummy variable is included to capture the balance sheet 'jump' that may result from such mergers. The group-level *Group Merger* variable is defined similarly. The *Crisis* dummy[57] is included to capture the regime change that has characterized banking since the onset of the euro-wide financial crisis in 2009. As such, this indicator variable is defined to take on a value of 1 in years starting with 2009, and 0 for periods before then. Subsidiary, banking group and host country fixed effects are also included in the analysis, as shown in the results tables at the end of the text. Robust standard errors are reported. Tables 3 through 5 describe the variables in detail. Table 3 gives detailed descriptions of the model's variables, Table 4 presents summary statistics, and Table 5 shows the correlation matrix of our variables.

6.4 Discussion of Estimation Results

Tables 1 through 4 in Appendix 8.7 display the results of our fixed effects panel data estimations.[58] Table 6 describes results of regressions that include bank (subsidiary-level) traits only (in addition to various sets of fixed effects). Table 2 describes the estimation results once banking group-specific variables are added to the regressions. Table 3 then expands Table 2's specifications by adding host country macro variables to the regressions. Lastly, Table 4 examines the financial crisis effects on bank lending by interacting each variable in the Table 3 specifications with the crisis dummy. The first three subsections

[57] This variable covers the entire financial crisis from 2009 onward. Given the close overlap in timing, we do not separately consider the Euro-crisis. Our data also suggest that a regime shift in lending began in 2009, and is still ongoing.

[58] In addition to including lagged values of the dependent variable among the covariates, we also estimate our models using the Arellano-Bond dynamic estimation technique. We do not find evidence of the role of dynamics in that our Arellano-Bond results are generally comparable to the fixed effects panel estimation results described in this section.

below focus on Tables 1 through 3, while the last subsection explores the role of the financial crisis (Table 4).

6.4.1 The Role of Bank (Subsidiary-level) Characteristics

We can strongly confirm our hypothesis that the burden of a high non-performing loan portfolio significantly hinders lending. Among the set of bank (subsidiary-level) characteristics, the non-performing loan ratio (NPL) has the strongest explanatory power in all cases (consistently significant at the 1 percent level). In all specifications, NPL has a significant negative effect on lending activity. The impact of a one percentage point increase in the one-year lagged NPL ratio of the CEE subsidiary of a foreign bank ranges from a 0.869 percent decline (in column 2 of Table 7) to a 1.337 percent decline (in column 4 of Table 3) in annual loan growth. Given that the median annual loan growth rate is 11.78 percent and the average is 16.82 percent, these effects are economically significant. The findings are in line with our expectations. The NPL ratio contains extensive information on the health of a bank. A high NPL ratio has consequences for the bank's profitability, capital position and liquidity position at the same time. In addition to these direct effects, high NPL ratios can also alter bank behavior by increasing banks' risk aversion and motivating more cautious lending policies. This indirect behavioral effect is another channel through which high NPL ratios may negatively impact lending. From the onset of the crisis, many countries (not only in the CEE region) took steps to help banks decrease their NPL ratios, because they found that a high NPL is a big burden which hinders the recovery of lending.[59]

Total asset size (in logs) has a significant negative effect on lending in almost every specification. Focusing on the significant coefficients only, a one percent increase in lagged total assets translates into anywhere from 1.779 lower (in column 1 of Table 3) to as much as 22.228 percent lower (in column 4 of Table 2) annual lending growth. A probable reason for this finding is that a given nominal value of issued loans corresponds to a higher annual growth rate for smaller banks who have a lower base of loan stock to grow from. Since in

[59] For instance, the members of the Vienna Initiative formed a working group to solve the problems of NPL.

our sample we focus on the important foreign-owned banks of the region, we do not think that there are big differences between banks in terms of their market power. It is also important to keep in mind that our sample starts in 2002. In most cases the transition of the banking system had just concluded by 2002, which is when the fast growth of loan portfolios began. As a result, the early years in our sample are characterized by higher loan growth rates and smaller bank sizes.

6.4.2 The Role of Banking Group Characteristics

Given the importance of Western banks in transferring know-how into less financially developed regions, one of our hypotheses is that parent bank traits have an important effect in shaping their subsidiaries' activities in the CEE region. Therefore, we include a set of parent bank characteristics in this next stage of our analysis. Two group traits that have consistent significant effects in our analysis are the group NPL and the group loan-to-deposit (LDR) ratios. The impact of a one percentage point increase in the NPL of the banking group ranges from 0.692 (column 3 of Table 2) to 0.917 (column 4 of Table 3) percentage point increases in lending flows. The comparable impact of the group LDR ratio, on the other hand, ranges from 0.106 (column 1 of Table 2) to 0.139 (column 1 of Table 3). Again, given that the median and mean annual growth rate of lending are 11.78 and 16.82, respectively, these effects are non-trivial. The positive signs on these variables imply that the lending capacity of the banking group does not have a limiting impact on their subsidiaries' activities. There are two possible explanations for this result. First, the NPL and the loan-to-deposit ratio contain information not only on the lending capacity or ability of the bank, but also on the bank's risk appetite. Higher initial NPL or loan-to-deposit ratios are the results of previous risk taking activities, which can also explain the higher pace of lending. The second explanation supplements the first one. The positive signs on the NPL and loan-to-deposit ratios might be driven by the first (pre-crisis) part of the sample. Indeed, Table 4 reveals that the size and significance of the group NPL and LDR effects vary across the crisis and non-crisis periods, which is explored in more detail below. In particular, these results on the role of the group LDR confirm our hypothesis that parent groups' balance sheet conditions have strong effects on their subsidiaries' lending.

6.4.3 The Role of Host Country (Macro) Characteristics

One of our testable hypotheses is that the Vienna Initiative helped maintain the amount of lending in the CEE region, following the Western banking groups' commitment not to withdraw funds from the CEE region. However, we find that the strongest and most consistent result in our extended specification is that the financial crisis had a significant negative level effect on bank lending even after we control for all other important subsidiary, parent and macro characteristics.[60] These findings are consistent with the onset of a crisis-induced regime change in bank behavior that previous literature has pointed to (Giannetti and Laeven, 2012; Temesvary, 2014). The crisis effects are consistently significant at the 1 percent level, with magnitudes ranging from -11.822 (column 4 of Table 1) to -22.225 (in column 3 of Table 3). Since the median and mean annual loan growth rates are 11.78 percent and 16.82 percent, respectively, these crisis effects are economically significant. Even though there were substantial cross-country differences in the post-crisis lending trends in our sample, an important common feature is that the post-crisis growth of lending could not reach the level which characterized these countries before the onset of the crisis. Our results on the quick and substantial reduction in the lending of foreign subsidiaries during the crisis is in line with the results of De Haas et al (2015). Based on De Haas and van Lelyveld (2014), the joint implication of the strong crisis effect result and the negative impact of parent liquidity conditions is that parent banks did not help their subsidiaries withstand the crisis in their host markets. This result motivates us to further study the effects of the financial crisis, as discussed below.

Interestingly, the country characteristics which show up most significantly in our specifications in Table 3 are those that pertain to the host country's level of debt. Three explanatory variables are significant: the long-term bond yield, the net external debt and the public debt levels of the recipient countries. A one percentage point increase in the one-year lagged long-term bond yield of the foreign subsidiary's host country corresponds to a range of 1.440 to 1.762 decline in annual lending growth. A one percentage point increase

[60] The level effect of the crisis remains very strong, even after we include a dummy variable which captures official statement of participation in the Vienna Initiative.

in the lagged external debt to GDP ratio of the host country corresponds to 0.245 decline in lending growth, while a comparable increase in the public debt to GDP ratio increases lending by a range of 0.194 to 0.363 percent. A technical explanation for this result is that there is no substantial cross-country variation in this variable in the sample. Most of the countries in the region (with the exception of Hungary) have relatively low public debt. For this reason, the public debt to GDP ratio may not be important in the assessment of the riskiness of these recipient countries (again, with the exception of Hungary). Long-term bond yields and external debt to GDP, which are more descriptive of the riskiness of a country, both enter with significant negative signs. These two measures contain a broad set of information on the overall performance of the macro-economy of a recipient country. External debt, in particular, aggregates the indebtedness of various sectors of a country's economy, and as such it can serve as a more precise indicator of the potential funding problems of a country.

6.4.4 The Role of the Financial Crisis

The financial crisis significantly affected the behavior of the banks and the macro-economies of the countries in our sample. Previous literature has established a significant crisis level effect on subsidiary lending (De Haas et al, 2015; Cull and Martinez Pereira, 2013; De Haas and van Lelyveld, 2014). However, there is evidence to suggest that not only did lending fall across the board, but the way in which bank traits affected lending behavior also changed during the crisis (Temesvary, 2014). We contribute to the literature by incorporating an analysis of these "slope" effects, i.e. how the roles of parent and subsidiary traits in lending changed during the financial crisis. We do so by interacting the set of explanatory variables discussed above with the crisis dummy. The results are shown in Table 4.

The subsidiary-specific non-performing loan ratio (NPL) remains significant throughout. Irrespective of whether we focus on the crisis or non-crisis subsample, NPL has a consistent significant negative effect on lending activity. While in the non-crisis period, the impact of a one percentage point increase in NPL on lending growth ranged from -0.949 to -1.105, these effects declined in magnitude during the crisis, ranging from -0.608 to -1.116. These effects are economically significant. It is important to note that there is great

variation in NPL across time periods, countries and banks. While the crisis negatively affected the loan portfolio across the board, in some countries the NPL ratio had returned to pre-crisis levels by the end of our sample (e.g. in Slovakia or the Czech Republic it is around 4 percent) while in others it is still very high (e.g. in Hungary it is close to 20 percent). Depending on banks' business model, the NPL ratio can differ significantly within the same country as well (e.g. it is generally higher for banks with higher exposure to the construction sector). Lastly, the evolution of NPL also shows variation. Some banks started the new millennium with a clean portfolio, and significant worsening could be observed only from 2009. However, others still had a bad "legacy" of loans at the start of our sample period. The combined implication of these facts is that the strong and consistent significance of NPL can be attributed to structural characteristics, and does not result from some idiosyncratic feature of the sample.

As described above, we hypothesized that subsidiary capitalization played no role in the pre-crisis era, since parent funding guaranteed a certain capital position. After the onset of the crisis, however, the relative role of local capital conditions became important as opposed to parent bank capitalization. The solvency position of banks became a crucial issue at the onset of the crisis, and many regulatory actions were taken to strengthen banks' capitalization. We are able to confirm this hypothesis on the changing role of subsidiary capitalization. Our results show that banks' capital position has had a positive effect on lending since the onset of crisis (since 2009), while before the crisis the capital ratio (capital divided by total assets) had no significant effect on lending. A one percentage point increase in the lagged capital to asset ratio of subsidiaries corresponds to a 1.640 to 2.403 percent increase in annual lending growth in the post-2009 period. The implication is that better lending ability of banks translates into higher lending activity. This result is in line with the findings of Popov and Udell (2012), who show that banking clients have less access to loans when banks experience a decline in capital ratios. Our results also support the finding of Frey and Kerl (2015) who find that subsidiaries' local performance acted as a stabilizing force in the supply of lending during the crisis.

It is interesting that the negative relationship between bank (asset) size and lending was more prevalent before the crisis. While the pre-crisis negative impact of asset size is

strongly significant across the specifications, after the onset of the crisis the impact of size is significant in only two of the five specifications. This finding supports the idea that the significance of bank size may be driven by technical reasons. A given nominal value of issued loans corresponds to a higher yearly percentage change for smaller banks who have a smaller loan base to begin with. Since the bank privatization process had just ended by the start of the new millennium, many banks began with a relatively low asset size at the start of our sample before they went through a period of high growth. In summary, the strong effects of bank-specific variables on lending suggest that supply-side factors play an important role in lending dynamics – even after controlling for shocks to the credit demand side.

Looking at the role of banking group traits, Table 4 reveals that the Loan to deposit ratio (LDR) is significant in most specifications, albeit with some variation. In the pre-crisis period, there is evidence that LDR had a significant positive effect on lending – with marginal effects ranging from 0.151 to 0.180. One interpretation is that banking groups which took higher liquidity risks in the pre-crisis period lent more through their subsidiaries as well. During the crisis, however, the LDR has a significant negative effect on lending, with marginal effects ranging from -0.058 to -0.067. This suggests that the worsening of a banking group's funding position in the crisis significantly reduced its subsidiaries' lending as well. These results line up with our expectations. Higher risk-taking by banking groups before the crisis negatively affected their foreign subsidiaries in the crisis. Our results on the negative impact of parent liquidity shocks on subsidiary lending are in line with previous papers (Popov and Udell, 2012; Cetorelli and Goldberg, 2011; De Haas and van Lelyveld, 2006, 2010, 2014; Giannetti and Laeven, 2012).

The Return on Assets ratio (ROA) of banking groups enters the regressions with a significant and positive sign in the pre-crisis period, with magnitudes ranging from 14.936 to 18.455. These effects are economically and statistically highly significant. There are two potential explanations for this result. First, in normal (non-crisis) times, higher returns widen the room for a greater scale and scope of activities. During the crisis, however, other considerations came to the forefront. Banks' decision makers became substantially more risk-averse during the crisis, and in many cases their ability to lend worsened significantly.

A second possible explanation pertains to the risk-taking behavior of bank managers. To the extent that there were big cross-sectional differences in managers' risk-taking and hence banks' ROA before the crisis, our result simply reflects the fact that banks with more risk-tolerant managers issued more loans during that time. The higher risk taking explanation is also supported by the result that banking group NPL had a positive effect on lending before the crisis in two out of the five specifications.

Lastly, our results indicate that country characteristics were not important in shaping the lending activity of foreign-owned banks in the pre-crisis period. In the crisis period, a host country's Net External Debt to GDP ratio is the only macro characteristic that enters with a significant effect. This variable had a significant negative effect on lending, but only during the crisis period – with marginal effects ranging in magnitude from -0.268 to -0.328. There are two potential explanations for the finding that external indebtedness of host countries has had a negative effect on the evolution of bank lending since the onset of the crisis. First, countries with high levels of external debt found balance sheet adjustments inevitable. Second, if the banking groups in our sample decided to shift their focus to countries with lower external imbalances, the significant result on this variable could be capturing the unobservable country traits that caused banks' cross-sectional shift of focus. This explanation is supported by the finding that the significance of net external indebtedness disappears once host country fixed effects are included.

6.4.5 Robustness checks

Newey-West standard errors. We also estimated each regression using the Newey-West autocorrelation-corrected robust standard errors, with one-year lags. The results obtained with and without explicit auto-correlation correction are very similar. Both the significance levels and the signs are the same for our key explanatory variables. Auto-correlation does not appear to be a pervasive problem in our estimates, as would also be suggested by the first-differenced nature of our variables.

Arellano – Bond dynamic panel estimation. As a robustness check, some of our models are re-estimated using the Arellano – Bond method. The results are generally in line with the results obtained from the comparable specifications estimated using the panel estimations described in the text above.

6.4.6 Adding an indicator of bank participation in the Vienna Initiative

An interesting question to examine is: How did the lending of banks which participated in the Vienna Initiative fare during the crisis, compared to those banks who did not participate? The commitment that participating banks took on in the context of the Initiative would suggest that such banks experienced *less* decline in their lending during the crisis, compared to banks which did not participate. In order to address this question, we repeated the estimation of Equation (5) with the inclusion of an indicator of participation in the Vienna Initiative for each bank. In categorizing Vienna Initiative participation, we consider only those subsidiaries whose parent bank made an official commitment to maintain exposure at a certain level. We base our classification on official statements of participation, even though many official and unofficial talks were organized for bankers, politicians and central bankers in the context of the Vienna Initiative. Since almost all the banks in our sample participated in in the talks in some capacity, our main results (excluding a specific Vienna Initiative dummy) remain valid. In our estimation containing the Vienna Initiative dummy we do not find a significant difference between the crisis effect on Vienna Initiative participating banks vs. banks which did not participate.

6.5 Summary and Conclusion

In this paper we studied the determinants of the lending trends of foreign banks in the Central and Eastern European (CEE) region since the early 2000s. Our analysis utilized a newly compiled dataset that contains detailed balance sheet and income data on Western European banking groups and their CEE subsidiaries, with annual frequency from 2002 to 2013. Using this dataset, we were able to identify the relative importance of bank subsidiaries' and their parent banking groups' balance sheet traits, as well as host country macro characteristics, in shaping the trends of foreign bank lending in the CEE region.

Our paper contributes to the existing literature in two ways. First, using our unique dataset we are able to simultaneously examine the role of parent banking group traits and subsidiary characteristics in driving CEE lending growth. We show that both are important: The efficiency, liquidity and profitability conditions of both the subsidiary and its parent banking group have strong effects on lending growth. Second, we examine how the onset of the financial crisis has affected the relationship between bank traits and lending. This

feature goes beyond the existing literature that has identified only a level effect of the crisis on lending. Indeed, we find substantial differences in how subsidiary and banking group traits affect CEE lending after the onset of the crisis relative to the pre-crisis period. For instance, we find that it is only after the crisis hits that the liquidity problems of parent banks have negative impacts on subsidiaries, and that strongly capitalized subsidiaries lend more. These patterns are not present in the pre-crisis period. Our results support the previous literature's conclusion that parent banks with relatively bad funding positions did not support their subsidiaries' lending during the crisis, resulting in a substantial decline of foreign bank lending in the CEE region (De Haas and van Lelyveld, 2014).

Our findings have several policy implications. First, our finding that high NPL ratios significantly hinder lending suggests that the acceleration of the cleaning up of bank balance sheets is essential in countries with portfolio quality problems. This is particularly important since economic recovery is more fragile and takes longer in the absence of a well-functioning banking system. The Vienna Initiative (2012) provides a broad summary on potential tools to help in the clean-up of impaired portfolios.

Second, our findings that parent group traits have a significant role in their subsidiaries' lending activity, and that this role has changed during the financial crisis, have policy relevance as well. The countercyclical capital buffer (BCBS 2010) has emerged as one of the most important topics in bank regulation. Basel III relies on the loan-to-GDP gap as the main criterion for the determination of the optimal countercyclical buffer. We find that higher risk taking by parent banking groups ahead of a crisis may lead to greater declines in the lending of their subsidiaries during the crisis. This result suggests that parent bank information should be included in the calculation of optimal loan-to-GDP ratios.

Finally, our results on the significant role of parent groups in their subsidiaries' lending suggests that closer cooperation between the supervisory authorities of parent banks' and subsidiaries' countries is essential. Although the establishment of the European Union's Single Supervisory Mechanism is a step away from country-level supervision, it is still not clear how host countries' interests will be represented in the supervisory decisions regarding banking groups active in the CEE region. The active involvement of host country decision makers should become an important part of the supervisory process.

Some important extensions remain, pending data availability. First, it would be instructive to examine the trends studied in this paper using higher frequency data on bank balance sheet conditions and lending. The gain in time-series variation (which would be particularly valuable in the crisis analysis) may reveal some additional important features. Second, it would be very interesting to carry out the same analysis using data on parent banking groups and their subsidiaries from other regions of the world as well. Comparing the behavior of foreign banks across regions (for instance, that of Western European banks in the CEE region with the behavior of U.S. bank subsidiaries in the Latin American countries) would make for some very instructive and important comparative analysis from a policy-making perspective.

7. REFERENCES

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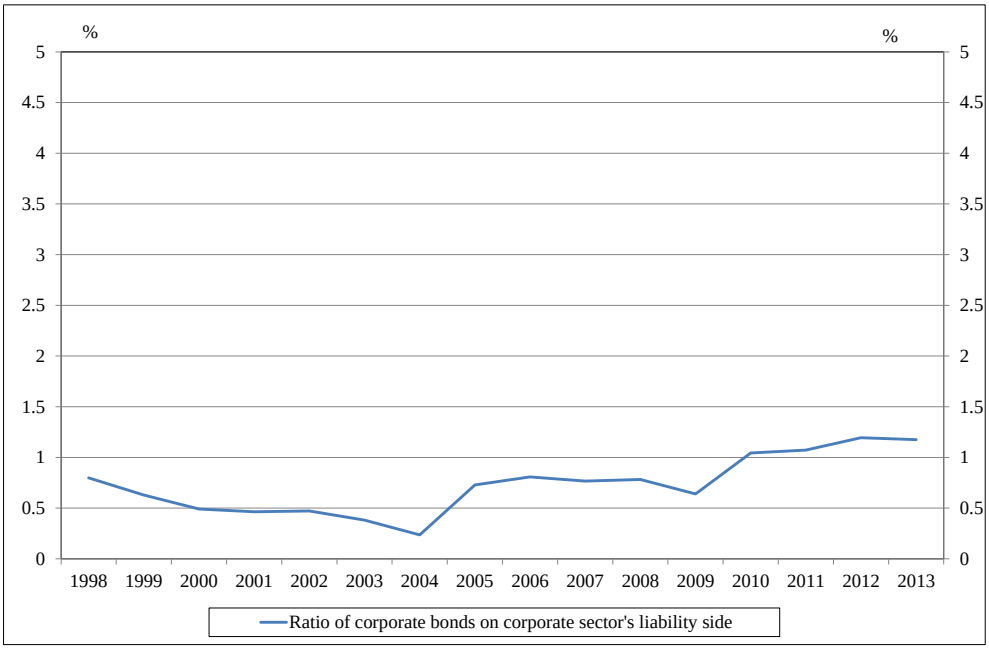
8. APPENDIX

8.1 Appendix of Chapter 3

	1-2 days	3 days-1 month	1 month-3 months	>3 months
Size (monthly graph)	• minimum 94 • 116 on average • „Decoupling" visible • decreases from Autumn 2008	• minimum 50 • 73 on average • „Decoupling" visible • decreases from Autumn 2008	• minimum 22 • 44 on average • „Decoupling" not visible • decreases from Autumn 2008	• minimum 18 • 41 on average • „Decoupling" not visible • decreases from Autumn 2008
Proportion of largest connected component	• usually >90%	• usually >90%	• usually >60% • once decreases to 40%	• usually >60% • twice falls under 30%
Type of graph	small world property • degree distribution follows power law • shortest path/size small • shortest path/log(size) constant • downward sloping affinity (disassortative) • diameter (5 on average) • mass function, high ratio of short paths • average clustering high	small world property • shortest path/size small • shortest path/log(size) constant • downward sloping affinity (disassortative) • diameter (6 on average) • mass function, high ratio of short paths • average clustering high, but lower than of 1-2 days	small world property less satisfied • according to shortest path/size it is closer to lattice • according to average clustering it is closer to random graph	no small world property
Effect of crisis	• degree dropped in Summer 2007 and Autumn 2008 • distances grew (shortest path, diameter, mass function, average closeness) • clustering fell • size decreased in Autumn 2008 • direction of cash flow between residents and non-	• the graph is smaller and denser from 2008 • distances increased in Autumn 2008 (shortest path, diameter, mass function, average closeness)	• diameter increased in Summer and Autumn 2007	• distances increased in Autumn 2008 • average degree and mass function increases since 2007 already • direction of cash flow between residents and non-residents changed in 2010
Exit of the actors on the periphery	visible • size • degree • shortest path • mass function • average closeness • average clustering • vertices of clustering of 0 and 1 • density	visible • size • degree • shortest path • mass function • average closeness • average clustering • vertices of clustering of 0 and 1 • density	visible • happens earlier (from end-2008 to end-2010)	not visible

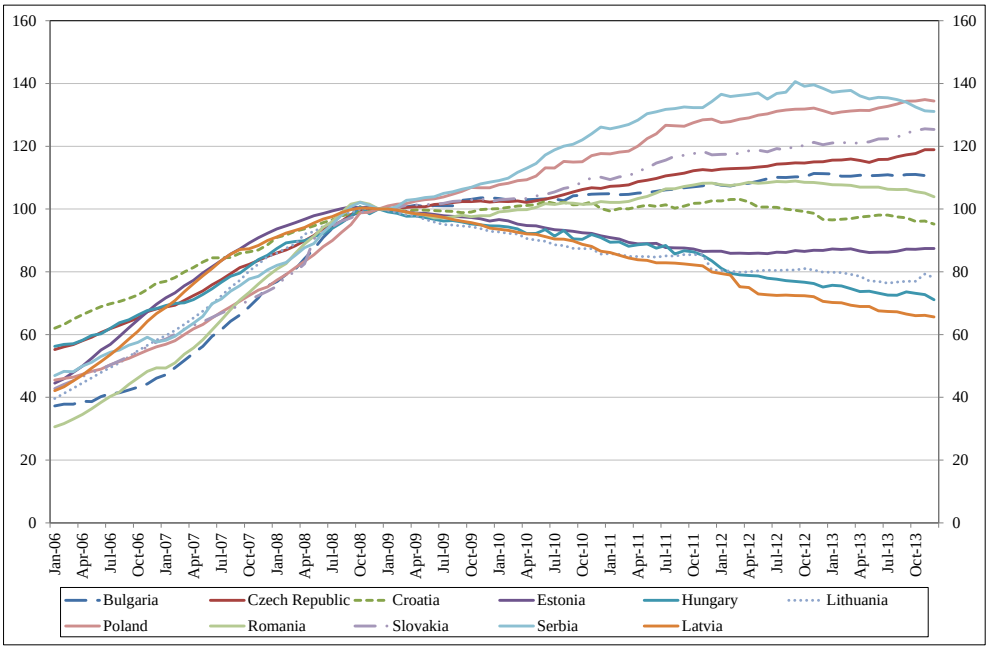
8.2 Appendix I. of Chapter 5

Chart 1: Capital market funds in the corporate sector



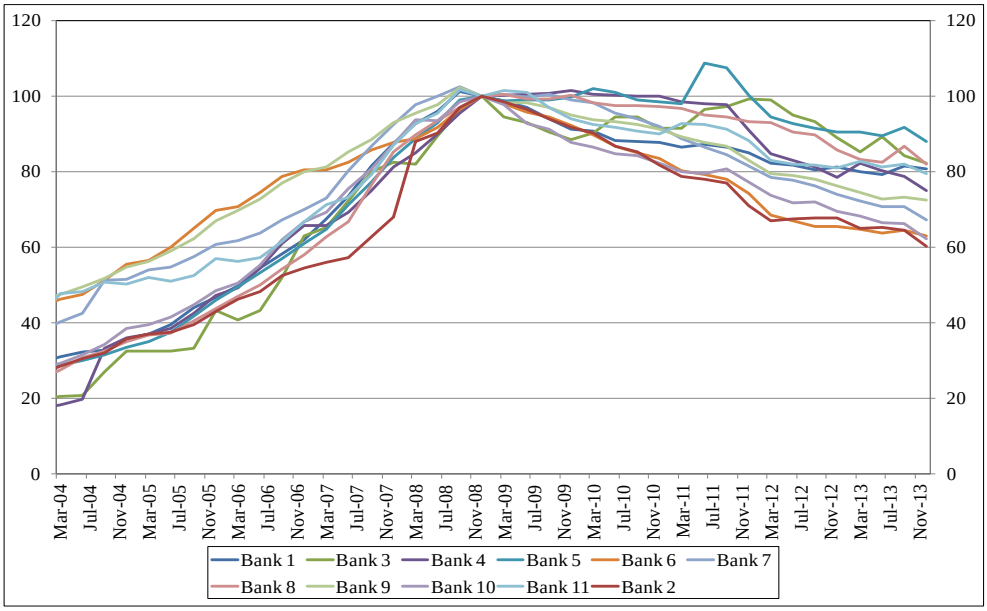
Source: central banks

Chart 2: Lending dynamics in the region (December 2008 = 100)



Source: central banks

Chart 3: Lending dynamics of the biggest Hungarian banks (December 2008 = 100)



Source: MNB

8.3 Appendix II. of Chapter 5

Table 1: Description of variables

Variable Name	Description	Source
Credit growth	Annual percentage change of loan stock	MNB
Loan to deposit (Q-4)	Total loan to total deposits lagged 4 quarters	MNB
FX swap (Q-4)	Net FX swap stock to total assets lagged 4 quarters	MNB
Liquid asset (Q-4)	Liquid assets to total assets lagged 4 quarters	MNB
Capital adequacy (Q-4)	Capital adequacy ratio after SREP lagged 4 quarters	MNB
NPL (Q-4)	NPL by classification categories lagged 4 quarters	MNB
Log total assets (Q-4)	Logarithm of total assets lagged 4 quarters	MNB
Loan to deposit - parent (Q-4)	Total loans to total deposits at parent groups lagged 4 quarters	Bankscope and Banks' financial reports
Capital adequacy - parent (Q-4)	Capital adequacy ratio at parent group lagged 4 quarters	Bankscope and Banks' financial reports
Leverage - parent (Q-4)	Total asset to capital at parent group lagged 4 quarters	Bankscope and Banks' financial reports
ROA - parent (Q-4)	Return on asset at parent group lagged 4 quarters	Bankscope and Banks' financial reports
GDP growth	Annual nominal GDP growth	KSH
HUF/EUR	HUF/EUR exchange rate	MNB
BUBOR 3 month	3 month BUBOR annual average	MNB
Household confidence	Consumer sentiment indicator	Eurostat

Table 2: Summary statistics of variables

Variable	Obs	Mean	Std. Dev	Min	Max
Credit growth	660	18.80	24.30	-32.59	100.00
Loan to deposit (Q-4)	578	133.08	49.64	34.02	450.15
FX swap (Q-4)	627	6.04	8.44	-21.00	36.00
Liquid asset (Q-4)	627	17.28	8.25	1.00	45.00
Capital adequacy (Q-4)	627	12.55	7.92	2.00	86.00
NPL (Q-4)	627	6.45	6.05	0.00	28.00
Log total assets (Q-4)	627	13.55	1.27	8.62	16.02
Loan to deposit - parent (Q-4)	436	155.29	70.37	79.53	468.80
Capital adequacy - parent (Q-4)	436	11.88	2.01	7.40	17.80
Leverage - parent (Q-4)	461	23.64	10.70	11.56	65.70
ROA - parent (Q-4)	461	0.34	0.55	-2.26	2.04
GDP growth	671	7.89	5.21	-2.87	18.39
HUF/EUR	671	264.25	18.95	235.90	311.13
Household confidence	660	-0.01	7.30	-29.60	17.00
BUBOR 3 month	671	9.09	3.11	4.28	18.11

Table 3: Correlation Matrix

	Loan to deposit (Q-4)	FX swap (Q-4)	Liquid asset (Q-4)	Capital adequacy (Q-4)	NPL (Q-4)	Log total assets (Q-4)	Loan to deposit - parent (Q-4)	Capital adequacy - parent (Q-4)	Leverage - parent (Q-4)	ROA - parent (Q-4)	GDP growth	HUF/EUR	Bubor 3 month	Household confidence
Loan to deposit (Q-4)	1													
FX swap (Q-4)	-0,2219	1												
Liquid asset (Q-4)	-0,1518	-0,2956	1											
Capital adequacy (Q-4)	0,1294	-0,0719	0,0753	1										
NPL (Q-4)	0,1129	0,0079	0,3297	-0,1182	1									
Log total assets (Q-4)	-0,0384	0,4098	0,0535	-0,4178	0,2331	1								
Loan to deposit - parent (Q-4)	0,1763	-0,1178	-0,2013	0,0325	0,0258	-0,3661	1							
Capital adequacy - parent (Q-4)	-0,0324	-0,1519	0,4385	0,0472	0,6216	0,1997	-0,0492	1						
Leverage - parent (Q-4)	-0,0743	0,5225	-0,0945	-0,2294	0,2103	0,5655	-0,3974	-0,0403	1					
ROA - parent (Q-4)	-0,2102	0,0927	-0,1014	-0,184	-0,2729	0,0794	-0,4257	-0,3424	0,4056	1				
GDP growth	-0,2341	-0,2529	-0,0076	0,0396	-0,4002	-0,5489	-0,072	-0,3712	-0,3117	0,2848	1			
HUF/EUR	0,211	0,0982	0,2265	-0,0452	0,6714	0,3716	0,0509	0,5085	0,247	-0,2998	-0,5931	1		
Bubor 3 month	0,1714	-0,0921	0,0083	-0,0152	-0,1372	-0,1845	-0,0279	-0,2351	-0,1624	-0,1008	0,0573	-0,0837	1	
Household confidence	0,0607	0,0037	0,0529	-0,0452	0,1309	0,0288	0,022	0,0629	0,0012	-0,1219	-0,1239	-0,0212	0,3075	1

8.4 Appendix III. of Chapter 5 - Results

Table 1: Regressions containing bank characteristics

Loan to deposit (Q-4)	-0.059	-0.060	-0.081	-0.081	-0.082	-0.084
	(0.014)***	(0.015)***	(0.016)***	(0.016)***	(0.016)***	(0.017)***
FX swap (Q-4)		-0.037	-0.143	-0.144	-0.141	-0.061
		(0.069)	(0.077)*	(0.076)*	(0.077)*	(0.078)
Liquid assets (Q-4)			-0.273	-0.275	-0.299	-0.256
			(0.080)***	(0.080)***	(0.082)***	(0.085)***
Capital adequacy (Q-4)				0.028	0.028	-0.221
				(0.236)	(0.234)	(0.233)
NPL (Q-4)					0.156	0.093
					(0.096)	(0.100)
Log total asset (Q-4)						-2.598
						(0.726)***
Merger dummy	47.244	47.467	48.130	48.212	48.248	47.802
	(7.517)***	(7.518)***	(7.586)***	(7.591)***	(7.583)***	(7.070)***
Crisis dummy	-28.366	-28.297	-26.764	-26.760	-27.922	-25.550
	(1.068)***	(1.069)***	(1.214)***	(1.205)***	(1.314)***	(1.315)***
Transition dummy	-0.632	-0.919	-0.415	-0.415	-0.519	-2.219
	(1.826)	(1.942)	(1.920)	(1.922)	(1.921)	(2.044)
Parent_dummy	4.246	4.253	4.110	4.192	4.010	-0.363
	(1.391)***	(1.395)***	(1.444)***	(1.696)**	(1.717)**	(1.910)
Earlyrepayment	-5.336	-5.291	-4.799	-4.758	-5.370	-5.645
	(1.048)***	(1.057)***	(1.022)***	(1.073)***	(1.147)***	(1.058)***
_cons	30.185	30.612	38.412	38.118	38.155	79.498
	(1.829)***	(2.127)***	(3.075)***	(4.080)***	(4.052)***	(11.508)***
R^2	0.63	0.63	0.64	0.64	0.64	0.65
N	578	578	578	578	578	578

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

This table depicts the impact of bank characteristics on banks' annual lending flows in their host countries. The dependent variable is defined as the annual percent change in the bank's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 2: Regressions containing subsidiary characteristics and controls on demand

Loan to deposit (Q-4)	-0.081	-0.082
	(0.018)***	(0.017)***
FX swap (Q-4)	-0.145	-0.071
	(0.082)*	(0.079)
Liquid asset (Q-4)	-0.229	-0.254
	(0.092)**	(0.086)***
Capital adequacy (Q-4)	-0.044	-0.175
	(0.242)	(0.236)
NPL (Q-4)	0.516	0.114
	(0.163)***	(0.119)
Log total assets (Q-4)	-1.963	-2.105
	(0.658)***	(0.720)***
GDP growth		0.369
		(0.287)
HUF/EUR		0.048
		(0.048)
Bubor 3 month		0.875
		(0.398)**
Household confidence		0.061
		(0.072)
Crisis dummy		-23.992
		(2.696)***
Transition dummy		-6.973
		(3.337)**
Earlyrepayment		-6.386
		(1.188)***
Merger dummy	48.488	47.463
	(6.121)***	(6.735)***
Parent dummy	0.202	0.448
	(2.054)	(1.934)
Time fixed effect	Yes	
_cons	60.668	48.916
	(11.475)***	(19.260)**
R^2	0.69	0.65
N	578	578

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

This table depicts the impact of bank characteristics and macro environment on banks' annual lending flows. The dependent variable is defined as the annual percent change in the bank's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Time fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 3: Regressions containing subsidiary and parent group characteristics

Loan to deposit (Q-4)	-0.110	-0.113	-0.114	-0.115
	(0.022)***	(0.021)***	(0.021)***	(0.021)***
FX swap (Q-4)	-0.064	-0.084	-0.043	0.004
	(0.093)	(0.103)	(0.109)	(0.111)
Liquid asset (Q-4)	-0.329	-0.317	-0.330	-0.342
	(0.090)***	(0.097)***	(0.097)***	(0.098)***
Capital adequacy (Q-4)	-0.748	-0.727	-0.741	-0.663
	(0.332)**	(0.337)**	(0.335)**	(0.332)**
NPL (Q-4)	-0.032	0.005	0.054	0.050
	(0.107)	(0.130)	(0.139)	(0.139)
Log total assets (Q-4)	-5.045	-5.042	-4.773	-4.678
	(0.977)***	(0.974)***	(0.963)***	(0.967)***
Loan to deposit – parent group (Q-4)	-0.027	-0.028	-0.033	-0.027
	(0.008)***	(0.008)***	(0.009)***	(0.010)***
Capital adequacy – parent group (Q-4)		-0.314	-0.475	-0.376
		(0.603)	(0.650)	(0.644)
Leverage – parent group (Q-4)			-0.716	-1.433
			(0.469)	(0.457)***
ROA – parent (Q-4)				4.419
				(1.292)***
Earlyrepayment	-6.284	-6.070	-6.081	-5.706
	(1.336)***	(1.389)***	(1.379)***	(1.365)***
Merger dummy	48.283	48.027	48.552	48.764
	(6.825)***	(6.902)***	(6.602)***	(6.591)***
Crisis dummy	-20.982	-20.681	-20.288	-17.798
	(1.721)***	(1.720)***	(1.791)***	(1.933)***
Transition dummy	-1.881	-2.244	-2.359	-1.879
	(2.480)	(2.815)	(2.836)	(2.842)
_cons	127.249	130.804	132.822	129.123
	(15.296)***	(16.069)***	(16.444)***	(16.741)***
R^2	0.67	0.67	0.67	0.67
N	436	436	436	436

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

This table depicts the impact of bank characteristics and parent group traits on banks' annual lending flows. The dependent variable is defined as the annual percent change in the bank's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 4: Regressions containing subsidiary and parent group characteristics and controls on demand

Loan to deposit (Q-4)	-0.126	-0.117
	(0.020)***	(0.021)***
FX swap (Q-4)	-0.254	-0.047
	(0.127)**	(0.114)
Liquid asset (Q-4)	-0.314	-0.345
	(0.101)***	(0.097)***
Capital adequacy (Q-4)	-0.547	-0.508
	(0.328)*	(0.340)
NPL (Q-4)	0.454	0.135
	(0.181)**	(0.147)
Log total assets (Q-4)	-4.273	-3.749
	(0.933)***	(1.001)***
Loan to deposit – parent (Q-4)	-0.029	-0.018
	(0.011)***	(0.011)*
Capital adequacy –parent (Q-4)	-0.563	-0.159
	(0.708)	(0.670)
Leverage – parent (Q-4)	-0.439	-1.187
	(0.486)	(0.472)**
ROA – parent (Q-4)	0.441	4.577
	(1.321)	(1.303)***
Merger dummy	46.604	48.405
	(5.733)***	(6.295)***
GDP growth		0.231
		(0.337)
HUF/EUR		0.008
		(0.054)
Bubor 3 month		1.198
		(0.475)**
Household confidence		0.048
		(0.082)
Crisis dummy		-16.744
		(3.373)***
Transition dummy		-6.153
		(4.093)
Earlyrepayment		-6.056
		(1.448)***
Time fixed effect	Yes	
_cons	123.690	96.446
	(19.213)***	(26.190)***
R^2	0.74	0.68
N	436	436

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

This table depicts the impact of bank characteristics and parent group traits and macro variables on banks' annual lending flows. The dependent variable is defined as the annual percent change in the bank's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Time fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 5: The main specifications with Newey-West standard errors

Loan to deposit (Q-4)	-0.084	-0.082	-0.115
	(0.025)***	(0.026)***	(0.029)***
FX swap (Q-4)	-0.061	-0.071	0.004
	(0.102)	(0.104)	(0.137)
Liquid asset (Q-4)	-0.256	-0.254	-0.342
	(0.139)*	(0.141)*	(0.151)**
Capital adequacy (Q-4)	-0.221	-0.175	-0.663
	(0.354)	(0.358)	(0.517)
NPL (Q-4)	0.093	0.114	0.050
	(0.172)	(0.196)	(0.215)
Log total assets (Q-4)	-2.598	-2.105	-4.678
	(1.175)**	(1.194)*	(1.461)***
Parent dummy	-0.363	0.448	
	(3.032)	(3.083)	
Merger dummy	47.802	47.463	48.764
	(11.674)***	(11.080)***	(11.190)***
Crisis dummy	-25.550	-23.992	-17.798
	(2.147)***	(3.840)***	(3.018)***
Transition dummy	-2.219	-6.973	-1.879
	(3.136)	(4.558)	(3.913)
Earlyrepayment	-5.645	-6.386	-5.706
	(1.577)***	(1.720)***	(2.035)***
GDP growth		0.369	
		(0.371)	
HUF/EUR		0.048	
		(0.060)	
Bubor 3 month		0.875	
		(0.580)	
Household confidence		0.061	
		(0.072)	
Loan to deposit – parent (Q-4)			-0.027
			(0.016)*
Capital adequacy –parent (Q-4)			-0.376
			(0.974)
Leverage – parent (Q-4)			-1.433
			(0.685)**
ROA – parent (Q-4)			4.419
			(1.983)**
_cons	79.498	48.916	129.123
	(17.918)***	(29.672)*	(25.195)***
N	578	578	436

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

This table depicts the impact of bank characteristics and parent group traits and macro variables on banks' annual lending flows. The dependent variable is defined as the annual percent change in the bank's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Time fixed effects are included as shown. Newey-West standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 6: Regressions controlling for crisis effects

	(1)	(2)	(3)
Loan to deposit (Q-4) – no crisis	-0.104	-0.105	-0.102
	(0.023)***	(0.023)***	(0.026)***
Loan to deposit (Q-4) - crisis	-0.044	-0.041	-0.029
	(0.026)*	(0.027)	(0.027)
FX swap (Q-4) – no crisis	0.054	0.089	-0.182
	(0.124)	(0.138)	(0.167)
FX swap (Q-4) - crisis	-0.005	0.018	-0.012
	(0.080)	(0.075)	(0.080)
Liquid asset (Q-4) - no crisis	-0.379	-0.392	-0.392
	(0.137)***	(0.139)***	(0.142)***
Liquid asset (Q-4) - crisis	-0.115	-0.029	-0.028
	(0.089)	(0.084)	(0.086)
Capital adequacy (Q-4) – no crisis	-0.180	-0.169	-0.187
	(0.331)	(0.345)	(0.355)
Capital adequacy (Q-4) - crisis	0.201	0.289	0.412
	(0.149)	(0.158)*	(0.181)**
NPL (Q – 4) – no crisis	0.955	0.890	1.151
	(0.375)**	(0.395)**	(0.422)***
NPL (Q – 4) - crisis	-0.222	-0.016	0.020
	(0.063)***	(0.076)	(0.112)
Log total assets (Q-4) – no crisis	-1.200	-0.921	-1.867
	(0.756)	(0.935)	(1.045)*
Log total assets (Q-4) - crisis	-3.643	-3.310	-1.840
	(0.745)***	(0.675)***	(0.507)***
Parent dummy – no crisis	2.905	3.205	2.074
	(2.778)	(2.993)	(3.316)
Parent dummy - crisis	0.404	0.022	2.356
	(2.506)	(2.399)	(2.349)
GDP growth – no crisis		0.159	
		(0.330)	
GDP growth - crisis		1.121	
		(0.441)**	
HUF/EUR – no crisis		0.058	
		(0.064)	
HUF/EUR - crisis		-0.022	
		(0.039)	
Bubor 3 month – no crisis		0.153	
		(0.478)	
Bubor 3 month - crisis		2.325	
		(0.602)***	
Household confidence – no crisis		0.028	
		(0.105)	
Household confidence - crisis		-0.110	

		(0.060)*	
Merger dummy	45.786	45.886	46.588
	(7.741)***	(7.838)***	(6.519)***
Earlyrepayment	-4.558	-6.982	
	(0.719)***	(0.886)***	
Time fixed effect			Yes
_cons	57.468	36.097	61.889
	(12.723)***	(19.077)*	(18.888)***
R^2	0.66	0.67	0.70
N	578	578	578

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

This table depicts the impact of bank, parent banking group and macro characteristics on subsidiaries' annual lending flows in Hungary during the financial crisis period and normal (non-crisis) times. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Time fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

8.5 Appendix I. of Chapter 6

Chart 1: Lending dynamics in the CEE region (31 December 2008 = 100, exchange rate adjusted)

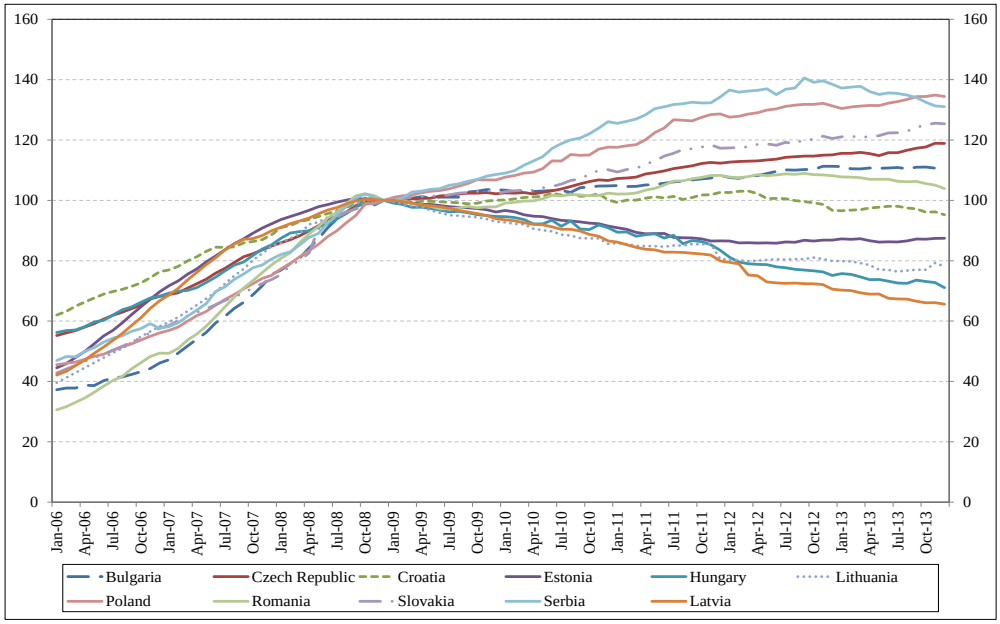


Table 1: Market share of foreign-owned banks in each banking systems based on total assets (%)

	Bulgaria	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Croatia	Poland	Romania	Slovak Republic	Serbia
2008	80	84	99	67	66	93	90	72	89	92	73
2011	77	83	94	66	65	90	91	69	82	92	74

Source: World Bank, IMF (2013), MNB, NBS

Table 2: Proportion of securities issued on the liability side of the corporate sector in CEE countries (%)

	Bulgaria	Czech Republic	Croatia	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovakia	Serbia
2012	N/A	4.11	3.71	2.48	1.19	0.14	0.07	2.90	0.07	0.53	N/A
Average of 2002-2013	N/A	2.63	2.18	1.77	0.78	0.40	0.21	2.32	5.50	1.24	N/A

Source: national central banks

8.6 Appendix II. of Chapter 6

Table 1: Description of variables and data sources

VARIABLE NAME	DESCRIPTION	DATA SOURCES
Subsidiary Characteristics		
Annual Lending Flows	Annual Percentage Change in Subsidiary's Stock of Loans	Bankscope and Central Bank Websites
Leverage Ratio	Subsidiary's Total Capital to Total Assets ratio	
Loan to Deposit Ratio	Subsidiary's Total Loans to Total Deposits ratio	
Non-performing Loans Ratio	Subsidiary's Non-performing Loans to Total Loans ratio	
Return on Assets	Subsidiary's Return on Assets, lagged on year	
Total Assets, logs	Subsidiary's Total Assets, log of	
Group Characteristics		
Group Leverage Ratio	Parent group's Total Capital to Total Assets ratio	Bankscope and Central Bank Websites
Group Loan to Deposit Ratio	Parent Group's Total Loans to Total Deposits ratio	
Group Non-performing Loans Ratio	Parent Group's Non-performing Loans to Total Loans ratio	
Group Return on Assets	Host Country's Public Debt to GDP ratio	
Group Total Assets, logs	Parent Group's Total Assets, log of	
Country Characteristics		
Public Debt to GDP Ratio	Host Country's Public Debt to GDP ratio	Economist Intelligence Unit
Annual GDP Growth	Host Country's Annual GDP Growth rate	
Long-term Yield	Host Country's Long-term Bond Yield	
Net External Debt to GDP	Host Country's Net External Debt to GDP ratio	
CPI Inflation	Host Country's Annual CPI Inflation	
Merger	Dummy variable to indicate merger activity of the subsidiary	Takes on value of 1 if merger occurs, 0 otherwise
Group Merger	Dummy variable to indicate merger activity of the Parent Group	Takes on value of 1 if group merger occurs, 0 otherwise
Crisis	Dummy variable to indicate onset of financial crisis	Takes on value of 1 starting in 2009, 0 otherwise

Table 2: Summary statistics of variables

VARIABLES	(1) min	(2) p25	(3) p50	(4) p75	(5) Max	(6) mean	(7) s.d.	(8) N
Group Total Assets, logs	7.903	11.58	12.56	13.74	15.08	12.49	1.45	713
Year	2,002	2,005	2,008	2,011	2,013	2,008	3.45	816
Public Debt to GDP Ratio	3.650	26.72	36.44	48.20	82.16	38.04	17.96	780
CPI Inflation	-1.130	2.30	3.92	6.33	22.16	4.97	4.012	780
Annual GDP Growth	-17.70	1.10	3.94	5.72	10.99	3.13	4.40	780
Long-term Yield	2.110	4.45	5.32	6.910	14	5.76	1.99	577
Net External Debt to GDP	5.050	27.64	46.03	65	135.5	49.87	27.86	762
Group Loan to Deposit Ratio	61.79	108.80	131.0	159.8	468.8	145.7	56.73	768
Group Non-performing Loans Ratio	0.120	2.32	4.40	7.68	44.86	5.90	5.88	717
Group Return on Assets	-10.83	0.21	0.53	0.87	4.429	0.45	1.086	775
Total Assets, logs	4.607	8.07	9.45	10.91	13.85	9.58	1.87	707
Annual Lending Flows	-137.8	0.006	11.78	28.66	182.1	16.82	27.71	634
Crisis	0	0	0	1	1	0.42	0.49	816
Leverage Ratio	-2.476	7.45	9.69	12.60	35.20	10.79	4.87	699
Group Leverage Ratio	-3.774	4.00	5.46	6.77	13.95	5.43	2.14	774
Loan to Deposit Ratio	17.42	82.43	109.0	139.6	584.9	124.4	74.40	635
Non-performing Loans Ratio	0.0659	2.69	5.23	10.73	35.60	7.60	6.73	503
Return on Assets	-14.31	0.73	1.28	1.86	5.22	1.08	1.81	634
Merger	0	0	0	0	1	0.081	0.27	816
Group Merger	0	0	0	0	1	0.13	0.34	816

Note: Outliers were excluded. Some unusual values like the negative leverage values were kept. We think that in those cases it is important to examine those periods when banks lost all of their capital. In these cases negative values have not been considered as outlier.

Table 3: Correlation matrix

	Leverage Ratio	Loan to Deposit Ratio	Non-Performing Loans	Return On Assets	Total Assets, logs	Group Leverage Ratio	Group Loan to Deposit Ratio	Group NPL Ratio	Group Return On Assets	Group Total Assets, logs	Public Debt to GDP Ratio	GDP Growth	Long-Term Yield	Net External Debt to GDP	CPI Inflation	Merger	Group Merger	Crisis
Leverage Ratio	1																	
Loan to Deposit Ratio	-0.12	1																
Non-performing Loans Ratio	0.14	0.09	1															
Return on Assets	0.16	-0.31	-0.52	1														
Total Assets, logs	0.2	-0.26	0.04	0.12	1													
Group Lever-age Ratio	0.07	-0.13	0	0.09	0	1												
Group Loan to Deposit Ratio	0.06	0.41	-0.01	-0.09	-0.09	-0.35	1											
Group Non-performing Loans Ratio	0.33	0	0.38	-0.07	0.17	0.02	0.12	1										
Group Return on Assets	-0.17	-0.12	-0.24	0.12	-0.11	0.52	-0.3	-0.48	1									
Group Total Assets, logs	-0.08	0.19	-0.09	0.02	0	-0.4	0.13	-0.23	-0.21	1								
Public Debt to GDP Ratio	-0.01	-0.14	0.3	-0.17	-0.05	0.12	-0.21	0.22	-0.07	-0.15	1							
GDP Growth	-0.11	-0.14	-0.37	0.31	-0.15	-0.14	-0.01	-0.34	0.25	-0.04	-0.27	1						
Long-term Yield	-0.12	0.29	0.27	-0.38	-0.25	0.04	0.09	0.08	-0.12	-0.02	0.32	-0.57	1					
Net External Debt to GDP	0	0.45	0.2	-0.21	-0.35	0.1	0.16	0.09	-0.1	0.26	0.22	-0.4	0.41	1				
CPI Inflation	0.28	0.09	-0.21	0.1	-0.12	-0.02	0.03	-0.09	0.1	-0.12	-0.02	0.33	0	-0.05	1			
Merger	0.14	0.06	0	0.04	0.07	0.17	-0.01	0.19	-0.08	0.25	0.03	-0.06	0.02	0.04	0.03	1		
Group Merger	0.16	-0.01	-0.03	0.06	0.06	0.21	-0.04	0.22	-0.08	0.3	0.09	-0.07	0	0.07	-0.03	0.76	1	
Crisis	0.21	0.19	0.33	-0.13	0.25	0.12	0.07	0.45	-0.36	0.18	0.16	-0.61	0.24	0.41	-0.31	0.16	0.14	1

8.7 Appendix III. of Chapter 6

Table 1: Impact of subsidiary lending characteristics on annual lending flows across subsidiaries' host countries

Annual Lending Flows (%)	(1)	(2)	(3)	(4)
Subsidiary Traits				
Leverage Ratio (t-1)	0.86	0.37	0.41	0.28
	(0.22)***	(0.40)	(0.43)	(0.47)
Loan to Deposit Ratio (t-1)	-0.08	-0.04	-0.05	-0.01
	(0.01)***	(0.02)**	(0.03)	(0.04)
Non-performing Loans	-0.94	-0.92	-1.03	-1.07
Ratio (t-1)	(0.14)***	(0.14)***	(0.14)***	(0.15)***
Return on Assets (t-1)	-0.50	-0.12	-0.26	-0.28
	(0.78)	(0.79)	(0.69)	(0.68)
Total Assets, logs (t-1)	-0.87	-5.08	-7.33	-18.19
	(0.61)	(1.75)***	(1.94)***	(4.14)***
Merger	9.98	0.33	9.37	20.86
	(4.36)**	(4.22)	(4.20)**	(8.29)**
Crisis	-21.60	-18.54	-16.85	-11.82
	(1.99)***	(2.16)***	(1.91)***	(2.04)***
Constant	38.51	74.81	90.20	218.37
	(9.15)***	(15.71)***	(18.41)***	(43.07)***
Banking Group fixed effects	Yes	No	Yes	No
Host country fixed effects	No	Yes	Yes	No
Subsidiary fixed effects	No	No	No	Yes
R^2	0.46	0.44	0.51	0.55
Observations	488	488	488	488

This table depicts the impact of subsidiary characteristics on subsidiaries' annual lending flows in their host countries. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and subsidiary and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 2: Impact of Subsidiary and Parent Banking Group Characteristics on Subsidiaries' Annual Lending Flows, across Subsidiaries' Host Countries

Annual Lending Flows (%)	(1)	(2)	(3)	(4)
Subsidiary Traits				
Leverage Ratio (t-1)	0.89	0.28	0.28	-0.16
	(0.25)***	(0.48)	(0.47)	(0.60)
Loan to Deposit Ratio (t-1)	-0.07	-0.03	-0.04	0.01
	(0.01)***	(0.02)*	(0.03)	(0.05)
Non-performing Loans	-0.89	-0.87	-1.01	-1.08
Ratio (t-1)	(0.16)***	(0.17)***	(0.16)***	(0.17)***
Return on Assets (t-1)	-0.07	0.14	0.11	0.18
	(0.90)	(0.87)	(0.78)	(0.75)
Total Assets, logs (t-1)	-0.59	-4.76	-6.86	-22.23
	(0.61)	(1.74)***	(2.18)***	(6.91)***
Merger	9.19	0.87	6.95	17.27
	(4.35)**	(4.39)	(4.00)*	(9.90)*
Banking Group Traits				
Group Leverage Ratio (t-1)	-0.39	0.37	-0.13	0.21
	(0.68)	(0.52)	(0.61)	(0.56)
Group Loan to Deposit	0.11	0.01	0.06	-0.01
Ratio (t-1)	(0.06)*	(0.03)	(0.06)	(0.06)
Group Non-performing	0.42	0.09	0.69	0.86
Loans Ratio (t-1)	(0.42)	(0.36)	(0.37)*	(0.38)**
Group Return on Assets (t-1)	1.02	-0.33	0.85	0.53
	(0.72)	(0.63)	(0.70)	(0.69)
Group Total Assets, logs (t-1)	-8.94	0.57	-3.49	6.12
	(3.91)**	(0.96)	(3.72)	(5.76)
Group Merger	10.97	-2.11	12.34	6.64
	(5.06)**	(3.37)	(4.97)**	(6.59)
Crisis	-20.74	-19.51	-18.85	-15.12
	(2.314)***	(2.17)***	(2.26)***	(2.18)***
Constant	122.88	62.91	116.23	187.11
	(44.11)***	(22.64)***	(39.58)***	(44.52)***
Banking Group fixed effects	Yes	No	Yes	No
Host Country fixed effects	No	Yes	Yes	No
Subsidiary fixed effects	No	No	No	Yes
R^2	0.48	0.44	0.52	0.57
Observations	469	469	469	469

This table depicts the impact of subsidiary and parent banking group characteristics on subsidiaries' annual lending flows in their host countries. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and subsidiary and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 %, ** at the 5 %, and *** at the 1 % level.

Table 3: Impact of Subsidiary, Parent Banking Group and Host Country Macro Characteristics on Annual Lending Flows, across Subsidiaries' Host Countries

Annual Lending Flows (%)	(1)	(2)	(3)	(4)
Subsidiary Characteristics				
Leverage Ratio (t-1)	0.90	0.34	0.31	-0.21
	(0.71)	(0.68)	(0.73)	(0.82)
Loan to Deposit Ratio (t-1)	-0.02	-0.01	-0.01	0.03
	(0.02)	(0.02)	(0.04)	(0.05)
Non-performing	-0.92	-1.05	-1.21	-1.34
Loans Ratio (t-1)	(0.18)***	(0.21)***	(0.21)***	(0.21)***
Return on Assets (t-1)	0.41	-0.18	0.13	0.16
	(0.93)	(0.84)	(0.83)	(0.83)
Total Assets, logs (t-1)	-1.78	-3.07	-6.58	-21.60
	(0.82)**	(2.21)	(3.14)**	(9.16)**
Merger	10.10	3.60	11.39	17.66
	(6.02)*	(6.19)	(5.72)**	(11.88)
Parent Banking Group Traits				
Group Leverage Ratio (t-1)	-0.35	0.41	-0.22	-0.10
	(0.91)	(0.66)	(0.83)	(0.79)
Group Loan to Deposit	0.14	0.02	0.12	0.04
Ratio (t-1)	(0.08)*	(0.03)	(0.07)*	(0.07)
Non-performing Loans	0.63	0.19	0.72	0.92
Ratio (t-1)	(0.53)	(0.46)	(0.49)	(0.49)*
Group Return on Assets (t-1)	1.53	-0.11	1.09	0.87
	(0.76)**	(0.69)	(0.75)	(0.75)
Group Total Assets, logs (t-1)	-4.63	0.85	-1.32	7.58
	(4.32)	(1.31)	(4.62)	(7.06)
Group Merger	14.10	-5.55	10.92	5.37
	(6.14)**	(4.46)	(6.41)*	(9.53)

This table depicts the impact of subsidiary and parent banking group characteristics on subsidiaries' annual lending flows in their host countries. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and subsidiary and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 3 continued: Impact of Subsidiary, Parent Banking Group and Host Country Macro Characteristics on Annual Lending Flows, across Subsidiaries' Host Countries

Annual Lending Flows (%)	(1)	(2)	(3)	(4)
Host Country Macro Traits				
Public Debt to	0.19	0.24	0.36	0.35
GDP Ratio (t-1)	(0.09)**	(0.19)	(0.17)**	(0.18)**
Annual GDP Growth (t-1)	-0.25	-0.16	-0.30	-0.32
	(0.29)	(0.28)	(0.28)	(0.28)
Long-term Yield (t-1)	-0.35	-1.76	-1.22	-1.44
	(0.52)	(0.70)**	(0.75)	(0.75)*
Net External Debt	-0.25	-0.12	-0.13	0.01
to GDP (t-1)	(0.08)***	(0.11)	(0.12)	(0.14)
CPI Inflation (t-1)	0.34	-0.17	-0.01	0.25
	(0.65)	(0.54)	(0.50)	(0.48)
Crisis	-20.20	-21.02	-22.23	-19.05
	(3.26)***	(3.35)***	(3.88)***	(3.51)***
Constant	75.24	54.75	81.98	153.39
	(46.81)	(29.07)*	(46.61)*	(61.01)**
Banking Group fixed effects	Yes	No	Yes	No
Host Country fixed effects	No	Yes	Yes	No
Subsidiary fixed effects	No	No	No	Yes
R^2	0.51	0.45	0.55	0.58
Observations	371	371	371	371

This table depicts the impact of subsidiary and parent banking group characteristics on subsidiaries' annual lending flows in their host countries. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and subsidiary and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 4: Impact of Subsidiary, Parent Banking Group and Host Country Macro Characteristics during the Financial Crisis and Normal Times, across Subsidiaries' Host Countries

Annual Lending Flows (%)	Period of Analysis	(1)	(2)	(3)	(4)	(5)
Subsidiary Traits						
Leverage Ratio (t-1)	Non-crisis	0.46	0.45	-0.15	-0.06	-0.69
		(1.16)	(1.22)	(1.22)	(1.27)	(1.31)
	Crisis	1.83	2.40	1.68	1.64	1.09
		(0.99)*	(1.10)**	(0.89)*	(0.85)*	(1.03)
Loan to Deposit Ratio (t-1)	Non-crisis	0.003	-0.02	-0.02	-0.01	0.02
		(0.03)	(0.03)	(0.04)	(0.04)	(0.05)
	Crisis	0.03	0.01	0.02	0.001	0.02
		(0.03)	(0.04)	(0.03)	(0.05)	(0.06)
Non-performing Loans Ratio (t-1)	Non-crisis	-0.96	-0.95	-1.11	-1.08	-1.01
		(0.32)***	(0.32)***	(0.31)***	(0.35)***	(0.37)***
	Crisis	-0.62	-0.69	-0.61	-0.81	-1.12
		(0.24)**	(0.24)***	(0.33)*	(0.29)***	(0.32)***
Return on Assets (t-1)	Non-crisis	1.02	1.25	1.60	2.28	2.73
		(2.38)	(2.43)	(2.01)	(1.91)	(1.66)
	Crisis	-0.63	-0.40	-0.64	-0.32	-0.54
		(0.68)	(0.72)	(0.76)	(0.93)	(1.07)
Total Assets, logs (t-1)	Non-crisis	-3.00	-2.89	-5.25	-8.15	-22.78
		(0.87)***	(1.02)***	(2.11)**	(2.91)***	(8.85)**
	Crisis	-1.36	-1.07	-3.79	-6.94	-23.08
		(1.01)	(1.07)	(2.52)	(3.06)**	(9.49)**
Merger	Non-crisis	20.21	25.58	19.57	24.94	27.41
		(16.08)	(16.17)	(16.18)	(15.88)	(16.62)
	Crisis	-0.04	1.49	-2.41	3.06	16.10
		(5.98)	(5.86)	(5.51)	(3.84)	(10.89)

This table depicts the impact of subsidiary, parent banking group and subsidiaries' host countries' macro characteristics on subsidiaries' annual lending flows in their host countries during the financial crisis period and normal (non-crisis) times. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 4 continued: Impact of Subsidiary, Parent Banking Group and Host Country Macro Characteristics during the Financial Crisis and Normal Times, across Subsidiaries' Host Countries

Annual Lending Flows (%)	Period of Analysis	(1)	(2)	(3)	(4)	(5)
Banking Group Traits						
Group Leverage Ratio (t-1)	Non-crisis	-1.75	-1.94	-1.69	-2.09	-2.82
		(1.78)	(1.83)	(1.80)	(1.77)	(1.83)
	Crisis	-0.40	-0.29	-0.17	0.05	0.57
		(0.79)	(1.01)	(0.76)	(0.93)	(0.92)
Group Loan to Deposit Ratio (t-1)	Non-crisis	0.05	0.18	0.04	0.15	0.08
		(0.04)	(0.08)**	(0.04)	(0.07)**	(0.07)
	Crisis	-0.07	0.05	-0.06	0.04	0.01
		(0.03)**	(0.07)	(0.03)*	(0.07)	(0.07)
Group Non-performing Loans Ratio (t-1)	Non-crisis	-0.04	2.42	0.27	2.22	1.80
		(0.86)	(1.13)**	(0.90)	(1.14)*	(1.19)
	Crisis	0.09	0.22	-0.07	0.44	0.73
		(0.58)	(0.64)	(0.59)	(0.55)	(0.56)
Group Return on Assets (t-1)	Non-crisis	14.94	17.50	14.14	17.30	18.46
		(6.14)**	(6.27)***	(6.11)**	(5.91)***	(6.28)***
	Crisis	0.31	1.04	0.09	0.62	0.14
		(0.58)	(0.81)	(0.54)	(0.74)	(0.76)
Group Total Assets, logs (t-1)	Non-crisis	3.00	-3.64	3.08	-0.57	6.48
		(1.68)*	(4.44)	(2.11)	(4.39)	(6.24)
	Crisis	0.58	-6.44	0.76	-2.29	6.18
		(1.45)	(4.56)	(1.44)	(4.53)	(6.99)
Group Merger	Non-crisis	-6.29	8.94	-6.48	7.66	4.86
		(6.35)	(8.03)	(7.04)	(8.52)	(10.39)
	Crisis	-5.96	18.77	-4.26	15.33	-2.04
		(6.10)	(8.95)**	(5.73)	(9.51)	(14.65)

This table depicts the impact of subsidiary, parent banking group and subsidiaries' host countries' macro characteristics on subsidiaries' annual lending flows in their host countries during the financial crisis period and normal (non-crisis) times. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

Table 4 continued: Impact of Subsidiary, Parent Banking Group and Host Country Macro Characteristics during the Financial Crisis and Normal Times, across Subsidiaries' Host Countries

Annual Lending Flows (%)	Period of Analysis	(1)	(2)	(3)	(4)	(5)
Public Debt to GDP (t-1)	Non-crisis	0.08	0.17	0.15	0.21	0.31
		(0.15)	(0.16)	(0.27)	(0.23)	(0.24)
	Crisis	0.21	0.23	0.27	0.19	0.22
		(0.13)	(0.15)	(0.22)	(0.24)	(0.27)
Annual GDP Growth (t-1)	Non-crisis	0.96	0.44	1.14	0.60	1.03
		(0.99)	(0.92)	(1.05)	(0.98)	(0.99)
	Crisis	-0.34	-0.40	-0.49	-0.37	-0.35
		(0.41)	(0.43)	(0.34)	(0.32)	(0.33)
Long-term Yield (t-1)	Non-crisis	-0.64	-1.53	-0.57	-1.13	-1.94
		(2.14)	(2.02)	(2.20)	(2.01)	(1.99)
	Crisis	0.35	0.42	-0.30	0.13	-0.08
		(0.64)	(0.68)	(0.85)	(0.94)	(0.92)
Net External Debt to GDP Ratio (t-1)	Non-crisis	-0.17	-0.15	-0.07	-0.10	0.03
		(0.12)	(0.13)	(0.18)	(0.16)	(0.17)
	Crisis	-0.33	-0.31	-0.27	-0.20	-0.12
		(0.11)***	(0.12)**	(0.16)*	(0.18)	(0.20)
CPI Inflation (t-1)	Non-crisis	-1.34	-0.94	-1.29	-0.72	-0.02
		(0.78)*	(0.81)	(0.87)	(0.86)	(0.84)
	Crisis	0.14	0.22	0.24	0.06	-0.18
		(1.24)	(1.32)	(1.16)	(1.05)	(1.05)
Constant		11.18	66.27	31.61	69.46	164.01
		(22.22)	(49.85)	(33.07)	(49.23)	(67.13)**
Banking Group fixed effects		No	Yes	No	Yes	No
Host Country fixed effects		No	No	Yes	Yes	No
Subsidiary fixed effects		No	No	No	No	Yes
R^2		0.52	0.57	0.53	0.59	0.62
N		371	371	371	371	371

This table depicts the impact of subsidiary, parent banking group and subsidiaries' host countries' macro characteristics on subsidiaries' annual lending flows in their host countries during the financial crisis period and normal (non-crisis) times. The dependent variable is defined as the annual percent change in the subsidiary's stock of loans (the annual difference of the natural logarithm of loan stocks, multiplied by 100). The coefficients indicate the percent change in annual lending flows induced by a one unit change in the explanatory variable. Host country (subsidiary location) and banking group fixed effects are included as shown. Robust standard errors are reported. * indicates significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

8.8 Appendix IV. of Chapter 6

The list of host (recipient) countries in the sample are: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Serbia, Slovakia. The list of source countries (locations of headquarters of bank groups) are: Austria, Belgium; Denmark, France, Germany, Greece, Hungary; Ireland, Italy, Netherlands, Norway, Portugal, Spain; Sweden, United States.

The list of banking groups in the sample are: KBC Group (Belgium); Erste Group (Austria); Societe Generale (France); Unikredit (Italy); Raiffeisen Group (Austria); Intesa Sanpaolo (Italy); Volksbank (Austria); ING (Netherlands); Alpha Bank (Greece); OTP Bank (Hungary); National Bank of Greece (Greece); EFG Eurobank (Greece); Commerzbank (Germany); Allied Irish Bank (Ireland); Banco Comercial Portugese (Portugal); Swedbank (Sweden); SEB Bank (Sweden); Danske Bank (Denmark); DnB Bank (Norway); Hypo Alpe Adria Bank (Austria); Bayerische LB (Germany); Bank Austria AG (Austria); Sanpaolo (Italy); HVB Bank (Germany); Raiffeisen Zentralbank (Austria); Santander (Spain);

The list of subsidiaries are: CSOB, K&H Bank, Kredyt Bank, CSOB Slovakia, Erste Bank Croatia, Česká spořitelna, Erste Bank Hungary, Erste Bank, Slovenská sporiteľňa, Banca Comerciala Romana, Societe Generale Expressbank, Splitska Bank, Komerční banka, BRD - Groupe Societe Generale, Societe Generale Bank Serbia, UniCredit Bulbank, Zagrebačka banka, UniCredit Bank Czech Republic, Unicredit Bank, HVB Bank Latvia, Bank Pekao, Unicredit Tiriac Bank, Unicredit Bank, Unicredit Bank Slovakia, Raiffeisenbank (Bulgaria) EAD, Raiffeisenbank Austria d.d. Zagreb (RBA), Raiffeisen Bank, Raiffeisen Bank Hungary, Raiffeisen Polbank, Raiffeisen Bank Romania, Raiffeisen Bank Serbia, Raiffeisen banka Slovakia, Privredna Banka Zagreb, CIB Bank, Banca Intesa, VÚB Banka, Volksbank Romania, ING Bank Śląski, Alpha Bank Romania, DSK Bank, OTP banka Hrvatska, United Bulgarian Bank, Bulgarian Postbank, Eurobank EFG, mBank, Bank Zachodni WBK S.A., Bank Millennium, Swedbank Estonia, Swedbank Latvia, Swedbank Lithuania, SEB Pank, SEB Bank, SEB Bankas, Danske Bank, DnB Nord Bank, DNB Bankas, Hypo-Alpe Adria Bank Croatia, Hypo-Alpe Adria Bank Serbia, MKB Bank, HVB Bank Slovakia, HVB Bank Biochim, HVB Bank Czech Republic, HVB Bank Romania

8.9 Appendix V. of Chapter 6 – Overview of CEE banking

The evolution of CEE banking showed similar trends after the collapse of the Soviet Union (the 'transition'). In the 1990s, all Central and Eastern European (CEE) countries went through a severe banking crisis that was in part caused by the legacy of the former economic system, in part by the lack of banking knowledge and in some cases, fraud. After the worst of the banking crisis was over, these countries had to rely on strategic foreign investors to stabilize their banking markets. The influx of foreign investors was important not only because internal savings were relatively low after the transition of the early 1990s, but also because professional banking was essential for long-term stability. The paragraphs below briefly describe the post-Soviet Union transition of CEE banking.

Hungary and Estonia were pioneers in the region's banking evolution, as these countries had already gone through banking crises over the 1992-1993 period. In Hungary, the aggregate Return on Equity (ROE) was minus 103 percent in 1993. While many primarily foreign-owned banks (mainly green-field investments) survived years of transformational crisis without major losses, certain Hungarian banks suffered losses amounting to several times their capital. Several factors contributed to the default of these Hungarian banks, such as the very poor quality portfolios inherited from the previous system and expansionary lending policy. A downturn in the corporate sector (caused in part by the introduction of a very strict bankruptcy law) rendered bank loans nearly worthless. In 1993, 47 percent of corporate debt was doubtful or bad. As part of the bank consolidation program of 1994, the state recapitalised its banks and strived to normalize portfolios. After the consolidation, the state tried to find strategic foreign investors who had the banking knowledge to operate these institutions safely in the long run. As result, by the mid-1990s the Hungarian banking system was dominated by foreign-owned banks (Banai et al. 2010).

The Estonian banking sector collapsed as early as 1992. A specific feature was that a new Estonian banking system had developed parallel to banks from the Soviet Union. After the collapse of the Soviet Union, it was not clear who was responsible for the supervision and regulation of these banks. Banking regulation was almost non-existent, and the minimum capital required for establishing a new bank was extremely low (partly due to the high inflation rates). The low standards for starting a new bank led to the establishment of many

new financial institutions. During 1991-1992, 30 new commercial banks were opened (Korhonen 1996). This banking boom, combined with the lack of regulation and knowledge, led to a banking crisis in 1992-1993. Over half of the existing banks closed their doors. Some of them merged with other banks, while others simply went out of business. Estonia granted permission to some foreign banks to open a branch in 1994. By the onset of the Asian financial crisis, almost half of the Estonian banking sector was foreign-owned. The Asian and the Russian crises of the late 1990s were a big test of the stability of the Baltic banking systems. Most of the Estonian banks survived the contagion, but these crises triggered some further consolidation: Two big Scandinavian banks (Swedbank and SEB) acquired the biggest Estonian banks, and foreign banks became dominant in the country.

Most non-Baltic CEE countries had experiences similar to the Hungarian case described above, while the other Baltic countries followed the Estonian pattern. The war in the former Yugoslavia caused some delays in the evolution of banking in Croatia and Serbia. The standards for banking market entry were relatively low in the CEE region, which contributed to the substantial wave of foreign bank entry. However, banking markets remained quite monopolistic in the immediate aftermath of the political and economic transition. This lack of competition was particularly beneficial to banks which had already built substantial market share by the time of the transition, while at the same time the lax regulatory framework helped conceal inherited ailments. Over time, however, the problems which eventually led to banking crises in the region gradually came to light (Banai et al. 2010).

In Poland, the foundation for the privatization of Polish banks was established by a program introduced in 1993. The state had to recapitalize several major banks over the 1993-1996 period. The privatization program was unsuccessful for a long time, as a large portion of state-owned banks could not be sold. The ratio of foreign ownership was still very low in the middle of the decade. Despite the delay, by the early 2000s over two-thirds of the banking system was in foreign ownership. The Polish national bank PKO was the only big bank which did not get a strategic foreign owner: The Polish state still owns a substantial portion of its shares (Banai et al., 2010).

In the Czech Republic, where the so-called "voucher privatization" hindered the appearance of prudent owners, several financial institutions went bankrupt in the 1994-1996 period. In the mid-1990s, the ratio of foreign ownership in the banking system was still insignificant. Due to the voucher privatisation, the state had to maintain its presence in the banking sector in order to ensure operability, given the large number of small shareholders. The four largest banks were nationalized in 1997 and 1998. In the 2000-2001 period, two large banks also required state intervention before they were taken over by foreign investors. Although this continued state presence delayed the arrival of foreign investors, by 2001 the Czech banking system was predominantly foreign-owned as well.

Privatization with compensation stocks in Slovakia was implemented in several waves, ending in 1995. In the following years, however, the banking system encountered severe difficulties. Several large banks required state help between 1997 and 2000. This period ended with a consolidation program designed in cooperation with the World Bank, which recapitalized strained banks and sold them to foreign investors (Barisitz, 2008). Due to the reform of the banking system, the ratio of foreign ownership in banking exceeded 90 percent by 2002.

In Bulgaria and Romania, the privatization of the banking system started as late as the end of the 1990s, due to the economic difficulties following the transition. In Bulgaria, several financial institutions went bankrupt over the 1996-1997 period, and the financial crisis soon spread to the real economy. The pursuant consolidation program brought an increase in foreign ownership in banking. Privatization more or less came to a close in 2003. The closing move was the sale of DSK Bank, the largest bank in 2003 (the investor was OTP Group).

Romania also experienced a severe banking crisis over 1997-1999. The first large privatization deal was carried out in 1999 (Barisitz, 2008). As in Hungary, only state intervention could solve the banking system's inherent problems. The worsening of bank portfolios in the mid-1990's led to a bank consolidation program (Várhegyi, 2001). The last step in the evolution of the Romanian banking system was the sale of Banka Comerciala Romana, the largest Romanian bank, to Erste Bank. As a result, foreign ownership rose to above 80 percent.

The build-up of banking activity took longer in Latvia and Lithuania than in Estonia. Similar to the Estonian case, these two countries were characterized by very lax bank regulation and supervision. In just a few years, the number of banks became extremely large relative to the size of the economy. This phenomenon was especially true for Latvia, causing this country to suffer the most severe crisis among the Baltic states. Both the Latvian and Lithuanian banking sectors collapsed in 1995 (Korhonen, 1996). Similar to the Estonian case, Asian and Russian crises contributed to the consolidation process. Big Scandinavian banks gained dominance by the late 1990s.

The economies and banking systems of Croatia and Serbia had somewhat different evolution paths after the transition than the other CEE countries. The political events of the 1990s hindered these countries' development. After the end of military conflict, the Croatian government first tried to stabilize the banking system during 1993-1995. In the framework of the bank rehabilitation act of 1994, the management teams of four big banks were replaced and the banks were recapitalized. From the mid-1990s, the increase in lending activity was partly fuelled by foreign currency savings. Due to the savings in foreign currency, the open FX position of the banking system became increasingly high. This risk materialized during the international financial crisis of the late 1990s. Some small and medium-sized banks had to exit the market, while others were part of M&A transactions. Most banks saw an increase in foreign strategic ownership after these transactions. As a consequence, the number of banks decreased significantly. The consolidation process had concluded by the early 2000s. Over 90 percent of the banking system (based on balance sheet totals) was foreign-owned by 2002 (Barisitz, 2008).

The evolution of the Serbian banking system took a long time. Over the past two decades, the legal name and borders of the country changed numerous times. This inherent instability hindered the smooth transition of the banking system as well. The Serbian banking system remained stagnant until the early 2000s. Most of the historically dominant banks suffered losses because of frozen assets and liabilities. The Serbian authorities started to rejuvenate the banking system in 2001, and they achieved the fastest progress in the CEE region by implementing ambitious restructuring measures. In the first round of reforms, 19 smaller banks were closed, and four out of the five biggest banks were liquidated in 2001.

The state tried to compensate the depositors and clean up the balance sheet of the banking system, causing the ratio of the banking system's balance sheet to GDP to fall from 127 percent to 36 percent by the end of 2002. The central bank's regulatory and supervisory power was also strengthened during this time. These actions laid the foundation for the long-term successful operation of the banking system. The majority of the banking system was sold to foreign strategic investors over 2004-2005. By the end of 2005, two-thirds of the banking sector was foreign-owned (Barisitz, 2008).