No 2017-09 – June

Working Paper

CEPII

Banks' leverage Procyclicality: Does Currency Diversification Matter?

Justine Pedrono & Aurélien Violon

Highlights

- A significant part of banks' balance sheet is diversified in terms of currency: on average 22% of total assets of banks located in France are denominated in USD in the period 1999-2015. The US dollar is the first foreign currency with 19% of total assets denominated in USD on average.

- Currency diversification reduces leverage procyclicality through credit risk diversification but it raises leverage procyclicality through the valuation channel of the exchange rate. Focusing on investment banks, the valuation effect dominates.

- As leverage procyclicality is mainly driven by the value of assets, currency mismatch is not determinant in theory. Our results confirm this theoretical prediction where a currency mismatch does not strongly affect leverage procyclicality.

- As currency diversification affects leverage procyclicality, our conclusions support the idea that currency diversification is an interesting candidate for micro and macro-prudential policy.

RESEARCH AND EXPERTISE
ON THE WORLD ECONOMY

Abstract

Currency diversification, which measures how much of assets are denominated in foreign currency, introduces a credit risk diversification and a valuation effect due to fluctuations of exchange rate. It affects banks' leverage responsiveness to the value of assets, namely the leverage procyclicality. Using novel micro data on banks' exposures, we confront theoretical conclusions by focusing on the US dollar diversification of banks located in France between 1999 and 2015. Distinguishing between commercial and investment banks, our analysis first supports previous empirical results where investment banks are more pro-cyclical than commercial banks. Second, our results show that the largest pro-cyclicality of investment banks comes from the effect of currency diversification, especially from the valuation effect of currency diversification which increases procyclicality. Finally, our results confirm the theoretical prediction where a currency mismatch does not strongly affect leverage procyclicality. Our conclusions support the idea that currency diversification is relevant to micro and especially macro-prudential policy.

Keywords

Banks, Procyclicality, Exchange Rate, Diversification, Balance Sheet, Financial Cycle, Financial Intermediaries.

JEL

F3, F4, G15.

Working Paper

CEPII

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CEPII Working Paper
Contributing to research in international economics

Editorial Director:
Sébastien Jean

Production:
Laure Boivin

No ISSN: 1293-2574

CEPII
113, rue de Grenelle
75007 Paris
+33 1 53 68 55 00

www.cepii.fr
Press contact: presse@cepii.fr

RESEARCH AND EXPERTISE ON THE WORLD ECONOMY

Banks' leverage procyclicality: does currency diversification matter?[1]

Justine Pedrono* Aurélien Violon†

The traditional models of financial accelerator from Bernanke and Gertler [1989], Kiyotaki and Moore [1997] posit that the procyclicality of asset prices amplifies booms and busts in financial cycles. During a boom asset prices increase which implies a strengthening of the banks' collateral value. Therefore, banks use their additional debt capacity to finance new credit. The ensuing credit expansion fuels cyclical upturn.

The 2008 financial crisis has redrawn researchers' attention on the financial accelerator and more precisely on leverage procyclicality. The link between financial accelerator and leverage procyclicality is straightforward. During booms, asset prices increase which - for a given value of debt - lowers leverage. If banks target a constant leverage ratio, they will increase their debt in order to restore initial leverage. In turn, leverage may be procyclical when banks take fully advantage of higher asset prices to raise their leverage ratio. Adrian and Shin [2014] show that the dynamics of leverage is then only constrained by the Value at Risk rule: during booms, banks extend their debt in order to keep their probability of default constant. Danielson et al. [2012] show that leverage procyclicality generates an endogenous mechanism similar to the financial accelerator.

Empirically, Adrian and Shin [2010] confirm the major five US investment banks' leverage procyclicality between 1997 and 2008. Kalemli-Ozcan et al. [2012] extend the analysis to large US and European banks. They confirm leverage procyclicality in the United States and in Europe. Focusing on European banks, Baglioni et al. [2013] find similar procyclicality in Europe and in the United States. As for universal banks in Europe, their leverage appears

[1]The views expressed here are those of the authors and do not necessarily represent those of the Banque de France. We thank Stefan Avdjiev, Agnès Bénassy Quéré, Olivier de Bandt, Catherine Koch, Patrick Pintus, Hyun Song Shin, as well as seminar participants at the BIS, the ACPR, the Banque de France, and the Aix Marseille School of Economics for very helpful comments. We are also indebted to the Aix Marseille School of Economics for financial and technical support provided during J. Pedrono PhD.

*CEPII, (justine.pedrono@cepii.fr), Aix-Marseille Univ., CNRS, EHESS, Centrale Marseille, AMSE
†Banque de France, ACPR, (Aurelien.VIOLON@acpr.banque-france.fr)

more procyclical than for US banks. Finally, looking at Canadian banks Damar et al. [2013], also confirm a procyclical leverage.

Angelini et al. [2009] provide a detailed analysis on the sources of financial procyclicality, but they do not include the potential impact of asset currency diversification. As banks hold domestic and foreign assets, they are exposed to both domestic and foreign financial cycles. Thus, their leverage procyclicality is dependent on international diversification. Depending on the correlation between asset prices and the exchange rate, currency diversification may also affect leverage procyclicality. Following Pedrono [2017], currency diversification includes two effects known as the diversification of credit risk and the valuation effect due to exchange rate fluctuations.[2] First, credit risk diversification reduces leverage procyclicality. Second, the valuation effect strengthens leverage procyclicality by promoting the asset that offers higher returns in the portfolio. These two channels of leverage procyclicality have not been studied in the empirical literature.

We propose an empirical analysis on the link between leverage procyclicality and currency diversification of assets. We use a novel micro dataset on banks located in France between 1999 and 2015. Following Baglioni et al. [2013] we also isolate investment banks from total universal banks to capture the heterogeneity in leverage procyclicity that can be explained by banks' activity. Currency diversification is defined as the share of dollar-denominated assets in the balance sheet. As highlighted by Borio and Disyatat [2011], Baba et al. [2009], McGuire and Von Peter [2012], European banks were largely involved in US money markets before 2008. This development induced some degree of currency diversification of both assets and liabilities. Focusing on banks located in France, the average share of total assets denominated in foreign currency was around 30% in 2000.[3] As US dollar is the main foreign currency in banks' balance sheets (24% of total assets in 2000 on average), we decide to focus on US dollar diversification.

Our results confirm the presence of leverage procyclicality for banks located in France between 1999 and 2015. However, commercial banks' leverage is less procyclical than investment banks' leverage, and the difference in leverage procyclicality is captured by currency

[2]The valuation effect concept comes from the literature on external asset positions. Following Gourinchas and Rey [2014], valuation gains - which can be attributed to currency and asset price movements - affect the external asset position of a country. In this paper, despite our focus is on banks' total assets positions, we use the same valuation effect definition.

[3]Source: Autorité de Contrôle Prudentiel et de Régulation ACPR, Banque de France

diversification. For investment banks, our results suggest that the effect of currency diversification is dominated by the valuation effect: currency diversification increases leverage responsiveness to the value of assets. By isolating the valuation effect, we are able to show that this channel affects significantly investment banks' leverage procyclicality. Additionally, our results confirm the theoretical prediction that currency mismatch does not affect leverage procyclicality. Hence procyclical leverage is only driven by the asset side of the balance sheet. Our conclusions support the idea that currency diversification is relevant to micro and especially macro-prudential policy.

The remainder of the paper is organized as follows. Section 2 provides a simplified theoretical framework based on Adrian and Shin [2010]. Section 3 describes the data set and provides details on the sample construction. Section 4 supplies descriptive statistics on currency diversification. In section 5, we explain our empirical approach, while results are presented in section 6. Section 7 concludes

1. A theory of leverage procyclicality

Following Adrian and Shin [2010, 2014], leverage procyclicality is derived from the definition of the Value at Risk (VaR) and the fact that banks manage their balance sheets dynamically. Considering a random variable A for the value of assets at a given horizon, the VaR can be defined as the maximum loss V on asset value A_0 with given probability. Formally, the Value-at-Risk at confidence level c relative to some base level A_0 is the smallest non-negative number V such that:

$$Prob(A \leq A_0 - V) \leq 1 - c \tag{1}$$

The VaR rule stipulates that banks maintain a sufficient amount of equity E to cover potential loss V such that:

$$E = V \tag{2}$$

To remain solvent, the bank adjusts its exposure when the situation is more risky. Thereby, it brings its VaR back in line with its equity.

Bank's leverage λ is defined as a ratio of total assets over equity such that:

$$\lambda = \frac{A}{E} = \frac{A}{V} = \frac{1}{v} \tag{3}$$

Where $v = \frac{V}{A}$ is the unit VaR that we can interpret as a risk premium. As demonstrated in Adrian and Shin [2010, 2014], v is counter-cyclical. Hence, leverage goes positively with total assets.

Introducing international diversification changes the definition of total assets. Denoting by A the domestic asset in domestic currency and $A^\star$ the foreign asset in foreign currency, total asset expressed in domestic currency is the sum of A and $SA^\star$ where S is the exchange rate. Leverage becomes:

$$\lambda = \frac{A + SA^\star}{E} = \frac{A + SA^\star}{V} = \frac{1}{v} \tag{4}$$

$$\text{where : } v = \frac{V}{A + SA^\star}$$

Adding a foreign asset changes the definition of the risk premium which now depends on both assets expressed in domestic currency. It follows that leverage is still positively related to total assets but this relationship depends on the degree of diversification. If the value of both assets is positively correlated but not completely, and if the exchange rate is fixed, the introduction of a second asset just diversifies the credit risk. Leverage procyclicality is thereby reduced.[4]

A floating exchange rate implies additional space capacity on the banks' balance sheets through a valuation effect. As the balance sheet is expressed in the domestic currency, the converting process raises the weight of the good asset within the bank's portfolio to the extent that return and exchange rate are positively correlated. The positive correlation between exchange rate and return implies an appreciation of the domestic currency when the domestic asset offers higher return than the foreign one. Although the Uncovered Interest rate Parity (UIP) predicts the opposite relationship, past empirical studies have regularly rejected UIP identity.[5] Using data from 1980 to 2000 on G7 countries, Chinn and Meredith [2004] confirm

[4] See Pedrono [2017] for theoretical proof.
[5] See Froot and Thaler [1990], MacDonald and Taylor [1992] for more details.

previous results and UIP failure, especially for short term maturity: the domestic currency tends to appreciate when domestic interest rates exceed foreign interest rates. By extending the analysis to 2011, Chinn and Quayyum [2012] still confirm positive correlation between exchange rate and returns for short term maturity. Alternatively, Ehrmann et al. [2011] use a structural VAR with daily data from 1988 to 2004. They show that a euro appreciation of 10 % is estimated to induce an increase in euro area financial markets of 5.7%. They also document an inverse causality where an increase of 100bp in euro area short rates leads to a 5.69% euro appreciation. Assuming a procyclical exchange rate, a floating regime thus implies a growing share of the asset that offers higher return in bank's portfolio. Space capacity on banks' balance sheets is increased. Compared to fixed exchange rate, the floating regime increases procyclicality.[6]

Hence, international diversification of assets is expected to reduce procyclicality through credit diversification and to increase it through currency diversification under a procyclical exchange rate.

Additionally, the theoretical results from Pedrono [2017] suggest that currency mismatch is irrelevant for leverage procyclicality. As leverage is driven by the composition of assets, currency diversification of liabilities does not affect the relationship.

2. Data set and sample construction

Our sample consists of domestic and foreign banks located in France. Data are collected by the French banking supervision authority ACPR. They are available on a yearly basis from 1999 to 2015. Because of bankruptcies, mergers and acquisitions, our panel is unbalanced. We have a total of 552 observations over the period with a minimum of 21 observations in 2013 and a maximum of 43 observations in 2006. The decline in yearly observations since 2006 can be partly explained by the rising concentration of the French banking system.

Our data cover all banks considered as "monetary institutions".[7] For the other banks, only those with a significant total asset in foreign currency are reported by ACPR. As a consequence, banks that are not subject to monetary statistic or banks with less than 800 million euros in foreign currency are excluded from our analysis.

[6] See Pedrono [2017] for theoretical proof.
[7] It includes all institutions that are large enough to be under the scope of the ECB for monetary policy.

Two sub-samples are then isolated. First, we keep banks which have a minimum of 5 year occurrence over the period. Alternativelly, we identify investment banks by following the methodology of Baglioni et al. [2013] and focusing on the type of liabilities the bank uses: a bank is identified as an investment bank if its average ratio of deposits to total debt is lower than the median value of the total sample over the period.[8] This definition of investment banks captures the degree of market based operations in liability, introducing then a first determinant of the heterogeneity in leverage procyclicality. On average, the deposit ratio of investment banks is equal to 25% while the deposit ratio of commercial banks is equal to 73%. The deposit ratio of commercial banks in our sample is comparable to the deposit ratio of commercial banks in the US over the same period.[9] Table 2, 3 and 4 in the appendix provide descriptive statistics on banks. On average, investment banks are larger and more leveraged, they are less diversified both in USD and in foreign currency and their off-balance sheets are larger.[10]

The final data set brings together two types of data. First, accounting data can be collected at different levels of consolidation depending on the banks. For large international banks, the data are consolidated using the IFRS accounting standards. Smaller parent banks provide consolidated data and use French accounting standards (FRGAAP). Finally, stand-alone banks provide unconsolidated data. Over years, consolidated data become more and more dominant. Since 2014, all the data are consolidated. As the three different levels of consolidation may imply different rules and definitions of the balance sheet components, it is controlled for it in our analysis.

The second type of data covers foreign currency exposures. On the asset side, we get the currency breakdown of credits and debt securities, while the liability side is composed of total deposits and debt issued. The currency breakdown is given for 5 major currencies: the euro, the US dollar, the Japanese yen, the Swiss franc and the Pound sterling.[11] As data are expressed in euro, the exchange rate channel is already included in the final degree of currency diversification.

[8] Other thresholds are used in robustness checks.
[9] The average deposit ratio of commercial banks in the US between 1999 and 2015 is equal to 72% (source: : Board of Governors, Federal Reserve, flow of funds).
[10] A complete definition of variables is developed in the appendix.
[11] The Pound sterling is only available since 2003. Before 2003, it is included in the "other" category.

Exposures in currencies are unconsolidated.[12] As our interest is on the global analysis of banking groups, we need to build a proxy for consolidated diversification. The solution we choose consists in adding up currency exposures of all affiliates in the same banking group. Thereby, currency diversification of a banking group is measured through a ratio of total amount denominated in a given currency relative to the total amount in all currencies.

This measure may raise two issues. First, there is a risk of a double counting because of intra-group flows. However, as long as diversification is a ratio, the double counting appears in both the numerator and the denominator, which mitigates the risk. Second, unconsolidated data do not include exposures of all affiliates abroad. Thus, this measure of currency diversification might underestimate the true degree of diversification of a banking group.

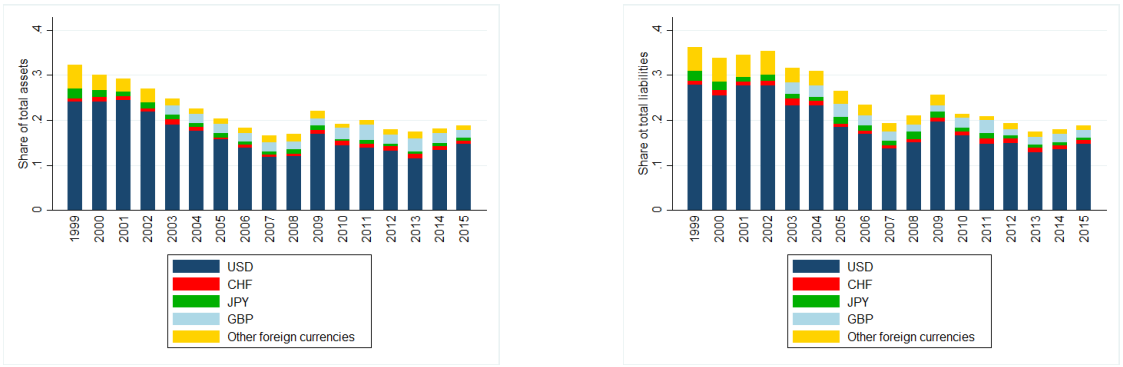
An alternative to this measure of currency diversification would consist in considering the exposures of the head quarter of the group only. In practice, the two measures are very close, except for cooperative banking groups. As cooperative banking groups are more decentralized, we believe that our measure better captures the overall currency diversification of these groups.

3. Descriptive statistics

Figure 1 provides the foreign currency breakdown of assets and liabilities from 1999 to 2015. For both sides of balance sheet, we observe a general decrease in currency diversification between 1999 and 2007. Although activities denominated in foreign currencies have increased in level as developed in Borio and Disyatat [2011], Baba et al. [2009], McGuire and Von Peter [2012], activities in euro have been even more dynamic during this period with banking integration within the euro area (Bouvatier and Delatte [2015]), explaining the decrease of currency diversification. A revival of currency diversification can be observed in 2008 and 2009, corresponding to the financial crisis and the appreciation of the dollar. Between 2010 and 2015, currency diversification in assets stabilizes while diversification of liabilities decreases slowly. Since 2013, the share of US dollars in total assets increases slowly.

With no surprise, Figure 1 highlights the US dollar as the first foreign currency for both

[12] Data on currency exposures (from DEVI_SITU) are collected at an individual level for all banks (unconsolidated data).



(a) Asset **(b)** Liability

Figure 1 – Currency breakdown of foreign currency exposures of banks located in France: The total bar for each year is the total foreign currency share in total assets or liabilities. Before 2003 exposures in GBP are included in the other foreign currencies category.
Source: ACPR, own calculations.

assets and liabilities. Figure 1 also underlines a potential currency mismatch between assets and liabilities with a dominance of the latter.[13] Focusing on US dollar exposures, Figure 2 confirms the currency mismatch by plotting the difference between assets and liabilities denominated in US dollar for each banking group. Despite the heterogeneity between banks, the pre-crisis period is characterized by a growing US dollar currency mismatch which confirms the balance sheet asymmetry. The crisis seems to have a readjustment effect where currency mismatches are reduced after 2007.

Figure 3 plots currency mismatch as a share of total assets for banking group hence controlling for bank size. Compared to figure 2, positive mismatches become more significant, whereas large negative currency mismatches disappear: banks with large and negative currency mismatches in level are also banks with large balance sheets. On average over the period 1999-2015, currency mismatch equals 1% of total assets for both investment banks and commercial banks. Figure 3 provides sufficient information to identify banks with significant mismatch, where mismatch is higher or equal to 5% of their assets. The blue bars in figure 3 sum banks with significant currency mismatch. For each year from 1999 to 2015, at least 10% of banks have a significant currency mismatch and this proportion reaches a 20% for 1999-2001, 2003-2004 and 2014.

[13] These results might seem different to McGuire and Von Peter [2012] - where net foreign positions for French banks are positive. However, we are looking at positions in foreign currencies whereas McGuire and Von Peter [2012] are interested in net foreign asset positions (including foreign assets and liabilities in euro). They also find negative net foreign positions in US dollar for several years before 2009.

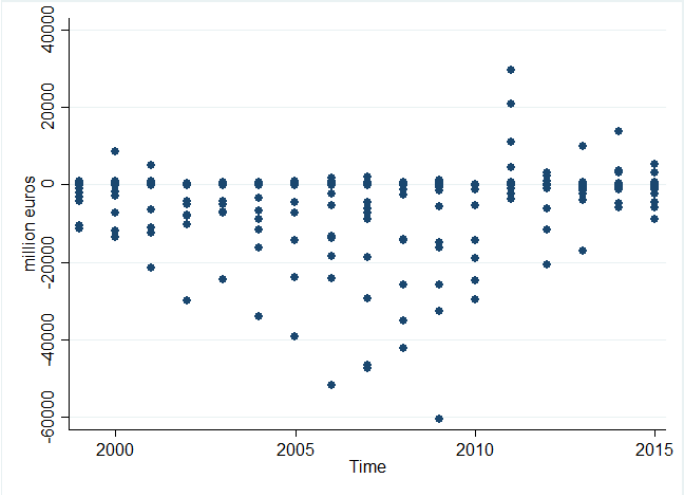


Figure 2 – US dollar mismatch by credit institution:
Total assets in US dollar minus total liabilities in US dollar. Each blue point represents a banking group located in France.
Source: ACPR, own calculations.

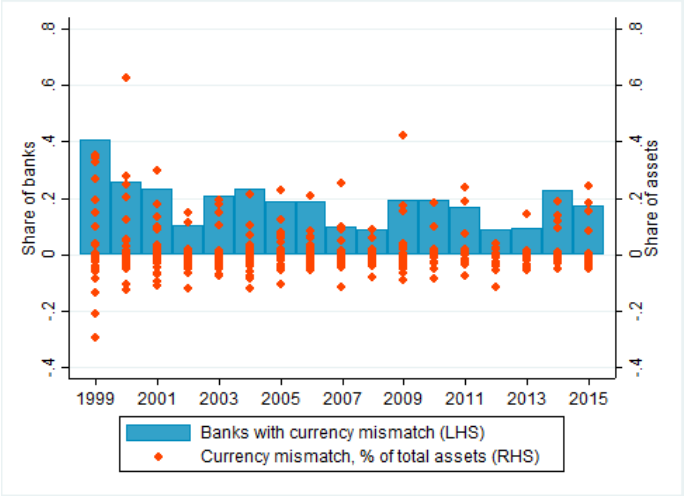


Figure 3 – Significant US dollar mismatch:
Red points indicates the currency mismatch of banking group as a share of total assets (right scale). Blue bars sum total banks with a currency mismatch (positive or negative) higher or equal to 5% of total assets (left scale).
Source: ACPR, own calculation.

Currency diversification implies two effects on total assets. First it introduces a diversification in credit risk if assets are sufficiently different. Second it induces a valuation effect due to the correlation between asset returns and the exchange rate. Figure 4 makes the distinction between resident and non-resident counterparts in US dollar diversification. As-

sets denominated in US dollar with euro area counterparts should not imply a credit risk diversification while assets on non-residents induce both effects of diversification. Between 2000 and 2007, the share of assets in US dollar with counterparts in the euro area increases. After the crisis, the share of non-resident counterparts increases.

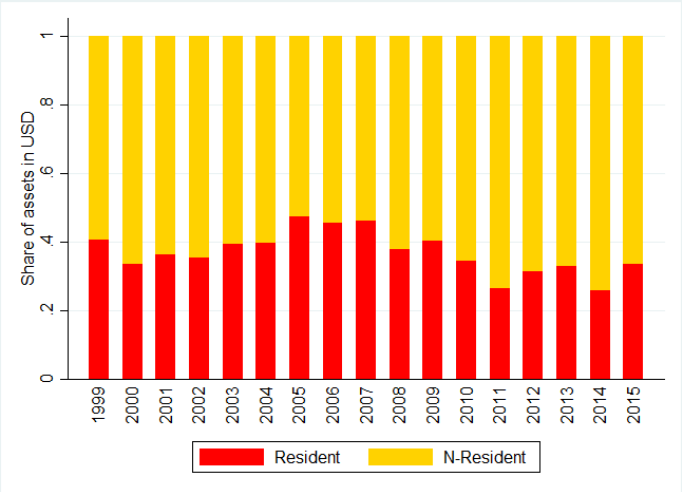


Figure 4 – Share of resident and non-resident in total assets in US dollar:
Resident includes all euro area counterparts while "N-Resident" excludes euro area counterparts. Bars are for average shares of assets in USD related to each counterparty. Only banks that have a US dollar diversification are included in this graph.
Source: ACPR, own calculation.

4. Econometric specification

Adrian and Shin [2008] use a panel regression for change in leverage, linking it with changes in asset value. By showing a strong and positive relationship, they demonstrate that financial intermediaries adjust their balance sheets actively. In their model, the dependent variable is the log variation of leverage $\Delta Leverage$ and the variable of interest is the log variation of total assets $\Delta Asset$. They also highlight that leverage is a mean reverting process with a negative relationship between the dependent variable and the lagged value of log of leverage $Leverage$. We first reproduce Adrian and Shin [2008] results by estimating the following equation:

$$\begin{aligned}\Delta Leverage_{i,t} = \alpha + \beta_1\, Leverage_{i,t-1} + \beta_2\, \Delta Asset_{i,t} \\ + \delta\, Controls_t + \gamma FE_t + u_{i,t}\end{aligned} \tag{5}$$

Where Δ represents the difference between t and $t-1$ and i is the bank subscript. We introduced three control variables in $Controls$. First, we define a ratio of total off-balance sheet to total assets and take the log-difference of it. This variable would control for hedging strategies. Second, we use a dummy $\Delta Conso$ which is equal to 1 when banks start to report consolidated data. Finally, we introduce another dummy $\Delta IFRS$ which is equal to 1 when credit institutions change to IFRS accounting standards.[14] Finally, we control time fixed effects FE_t in order to capture crisis periods and changes in regulation. $u_{i,t}$ is the term of error.

As explained in Section 2, currency diversification could challenge leverage procyclicality through its impact on total assets. We supplement Adrian and Shin [2008] specification by interacting changes in assets with lagged US dollar diversification.[15] We also add $Divers$ as a control variable. $Divers$ is part of the control variables as our interest is really on the interaction term. The complete specification is of the form:

$$\begin{aligned}\Delta Leverage_{i,t} = \alpha &+ \beta_1\ Leverage_{i,t-1} + \beta_2\ \Delta Asset_{i,t} \\ &+ \beta_3\ (\Delta Asset_{i,t} \times Divers_{i,t-1}) + \beta_4\ Divers_{i,t-1} \\ &+ \delta\ Controls_t + \gamma FE_t + u_{i,t} \end{aligned} \tag{6}$$

As we want to see whether the currency mismatch is relevant or not to leverage procyclicality, we introduce another specification where the dummy $Mismatch$ replaces the previous currency diversification. $Mismatch$ isolates banks with significant currency mismatch: it is equal to 1 if the absolute value of currency mismatch is higher or equal to 5% of bank's total assets.

$$\begin{aligned}\Delta Leverage_{i,t} = \alpha &+ \beta_1\ Leverage_{i,t-1} + \beta_2\ \Delta Asset_{i,t} \\ &+ \beta_3\ (\Delta Asset_{i,t} \times Mismatch_{i,t-1}) + \beta_4\ Mismatch_{i,t-1} \\ &+ \delta\ Controls_t + \gamma FE_t + u_{i,t} \end{aligned} \tag{7}$$

[14] We believe that banks' adjustment relative to accounting standards are relevant to the variation in leverage only at the period of introduction.

[15] Our variable of interest is constructed by interacting an exogenous term $Divers$ with the potentially endogenous variable $\Delta Asset$. As we control for the effect of the endogenous variable, our interaction term can be interpreted as exogenous (Angrist and Krueger [1999]). See also Bun and Harrison [2014] for a related discussion.

5. Empirical findings

5.1. Results for 1999-2015

The results over the whole period are displayed in Table 6. They are consistent with Adrian and Shin [2008]. In particular, we can confirm the mean reverting process of leverage. All coefficients relative to the growth rate of assets are positive and significant thereby confirming leverage procyclicality. The largest level of leverage procyclicality is observed when we focus on investment banks with repeated occurrences (column (5) and column (7)).

Our main variable of interest - the interaction variable between the growth rate of assets and the lagged currency diversification - is positive for all samples and significant for investment banks (column(6) and column(8)). Comparing results from equation (5) to results from equation (6) show that currency diversification affects leverage procyclicality when focusing on investment banks, and it explains the largest level of leverage procyclicality of investment banks. However currency diversification encapsulates credit risk diversification that has opposite effect to the pure currency diversification effect in our theoretical model. Our measure of currency diversification does not allow us to distinguish between the credit risk diversification and the valuation effect due to exchange rate fluctuation.

Instead of using the total US dollar diversification of assets, we now use the US dollar diversification of assets with domestic counterpart Divers_RES to capture the pure valuation effect. As assets are linked to residents only, this new measure removes the credit risk diversification. Table 7 reports the results with the variable Divers_RES. Our main variable of interest - the interaction term between the growth rate of assets and the US dollar diversification - is now positive and highly significant for investment banks. These results confirm the presence of a valuation effect of currency diversification on leverage through the dynamics of total assets. Therefore, our results confirm the presence of two opposite effects within currency diversification. There is a positive valuation effect and a negative credit risk diversification effect. Our results support the theoretical conclusions of Pedrono [2017].

In table 8, we introduce the currency mismatch dummy consistent with the theory (Pedrono [2017]). The coefficients are insignificant for almost all samples except for investment banks where the coefficient is positive and weakly significant (column (3)). Introducing this additional variable does not increase the adjusted R^2 compared to the previous table. As

leverage is mainly driven by collateral, currency mismatch is not expected to affect leverage procyclicality.

5.2. A two-period decomposition

The 1999-2015 period covers two main sub-periods. The 1999-2007 is characterized by growing leverage and a continuous appreciation of the euro from the end of 2000. From 2008 to 2015 the euro area financial system suffers massive shocks. Additionally, the second sub-period is characterized by a renewal of regulation and a deleveraging. Therefore, the two sub-periods decomposition allows us to see whether the relationship is symmetric or not for rising and declining asset values.

Table 9 decomposes the 1999-2015 period into pre-crisis and the post-crisis. Results from Adrian and Shin [2008] are still valid. Conversely, the role played by US dollar diversification of assets seems to be more specific to sub-periods. Regarding the interaction term, our results suggest that the post-crisis sub-period is much more relevant for the impact of currency diversification. Coefficients are positive and significant for all samples.

We exclude 2008 and 2009 from the post-crisis period to see whether the asymmetry depends on the financial crisis itself. The interaction term for the post-crisis in Table 10 is now insignificant. 2008 and 2009 imply unprecedented and unexpected events. Once the 2008-2009 period is removed, our results suggest that the relationship between leverage procyclicality and currency diversification is symmetric and significant for investment banks.

5.3. Robustness checks

The largest procyclicality of investment banks is relative to the complete sample of banks. In column (1) of table 11, estimations are reported for commercial banks when diversification is based on US dollar. The procyclicality of leverage is not altered by currency diversification. Comparing to column (6) of table 6, commercial banks' leverage is less procyclical than investment banks because of currency diversification.

We might think that multiple correlations introduced by several foreign currencies cancel valuation effects. As banks' portfolios imply more than one foreign currency, we extend our analysis to total foreign currency diversification defined as the share of assets denominated in foreign currency. This new measure captures the complete currency pattern of banks'

balance sheets. Results related to investment banks are in Table 11 column (2) and (3). Like for the US dollar diversification, we isolate the foreign currency diversification vis-à-vis residents in (3). For both counterparts, coefficients and significance of variables are quite similar to previous results on US dollar diversification. Our results suggest that including foreign currency exposures does not remove the valuation effect. Currency diversification is still significant.

Instead of using a 5% threshold to identify banks with significant mismatch, banks are now defined as significant when there mismatch - positive or negative - is higher or equal to 1%, 2.5% or 7.5% of their total assets. Results relative to investment banks are reported in column (4), (5) and (6) of Table 11. Our results supports previous conclusions where banks' mismatch does not strongly affect leverage procyclicality.

In columns (7) and (8) of Table 11 we change the definition of investment banks. First, we keep the 40 percentile value of the deposit ratio instead of the median in (7): a bank is defined as an investment bank when its average deposit ratio is lower than the 40 percentile value. Consequently, investment banks within the total sample decrease. Then in (8), we use the 60 percentile value of the deposit ratio instead of the median, leading to an increase of investment in the total sample. In both specifications, the interaction variable between the growth rate of assets and the lagged US dollar diversification is still positive and significant.

Finally, it might be interesting to underline the fact that off-balance sheet ratio is not irrelevant to the leverage analysis except when we focus on a reduced sub-sample of investment banks. Our results suggest that currency diversification has to be included in banking monitoring even though banks have hedging strategies.

Conclusion

Using an innovative data set on credit institutions located in France between 1999 and 2015 enables us to examine whether currency diversification is relevant to leverage procyclicality. Theoretically, as currency diversification implies a credit risk diversification and a valuation effect, it changes banks' debt capacity and the procyclicality of their leverage.

This paper fills the gap in the empirical literature which does not include currency diversification in the determinants of leverage procyclicality. It also provides novel descriptive statistics on foreign currency exposures for banks located in France.

Our results confirm previous conclusions on leverage procyclicality where the leverage procyclicality of investment banks is larger than the leverage procyclicality of commercial banks. Furthermore, they suggest that currency diversification is relevant to the analysis of the leverage procyclicality of investment banks . The valuation effect dominates over the credit diversification effect. Therefore, currency diversification increases leverage responsiveness to asset value: the difference in leverage procyclicality between commercial and investment banks is captured by currency diversification. Additionally, our results confirms the theoretical prediction where currency mismatch does not affect leverage.

The effect of currency diversification depends on the type of banks and the sub-period decomposition. Currency diversification expresses itself more easily within investment banks. Our results also suggest that the 2008 2009 crisis had specific effect in terms of valuation while the relationship between leverage procyclicality and currency diversification seems to be symmetric betwwen 1999-2007 and 2010-2015.

Four policy implications can be derived from these results. First, as currency diversification is not neutral, regulators should monitor the degree of currency diversification in addition to geographic diversification. Second, as the heterogeneity in leverage procyclicality is mainly explained by the currency denomination of assets compared to currency mismatch, regulators could calibrate regulatory instruments with the level of currency diversification. Third, as the valuation effect dominates over the credit diversification effect, introducing efficient instruments to hedge foreign exchange rate risk might decrease leverage procyclicality of investment banks. Finally, and regarding the introduction of the Basel III leverage ratio at 3%, our results suggest that this regulatory ratio is more restrictive for investment banks because of the currency diversification effect.

Appendix

Table .1 – Variable definitions.

Main variables:	
$Leverage$	$In\left(\frac{Assets}{Equity}\right)$
Δ $Leverage$	Growth rate of leverage
Δ $Asset$	Growth rate of assets expressed in euro
$Divers$	$\frac{Assets\ denominated\ in\ USD}{TotalAssets}$
$Divers\_RES$	$\frac{Assets\ denominated\ in\ USD\ with\ resident\ conterparty}{TotalAssets}$
$Invest.$	=1 if $\left(\frac{Deposits}{Total\ Debts}\right)_i < \left(\frac{Deposits}{Total\ Debts}\right)_{median(i...N)}$
$Mismatch$	=1 if |Currency Mismatch| $\geq$ 5% of Assets
Controls:	
FR	=1 if banks are french
$Sub\,Cat.$	Breakdown credit institutions between banks, cooperative banking groups and other
$Conso$	=1 if data are consolidated
$\Delta Conso$	Changes in $Conso$
$IFRS$	=1 if banks report data using IFRS standards
$\Delta IFRS$	Changes in $IFRS$
$Off\ BS$	$\frac{Off-balance\ sheet}{Assets}$
$\Delta Off\ BS$	growth rate of $Off\ BS$

Table .2 – Summary statistics: all banks

Variable	Mean	Std. Dev.	Min.	Max.	N
Leverage	16.01	12.63	1.14	78.68	552
Δ *Leverage*	-0.02	0.25	-1.43	1.19	465
Size	8.6	2.77	4.7	14.2	552
Δ *Size*	0.03	0.22	-1.6	1.1	465
Diver(USD)	0.17	0.2	0	0.84	552
Diver(USD RES)	0.05	0.09	0	0.67	552
Diver(All)	0.22	0.23	0	0.88	552
Diver(All RES)	0.07	0.1	0	0.67	540
Mismatch(5%)	0.19	0.39	0	1	552
Off BS	0.29	0.48	0	4.02	552

These summary statistics are for the complete sample over the period 1999-2015. This table presents variable averages, standard deviation, minimum and maximum. Variable definitions are provided in the appendix.

Table .3 – Summary statistics: investment banks

Variable	Mean	Std. Dev.	Min.	Max.	N
Leverage	17.85	14.15	1.2	78.68	273
Δ *Leverage*	-0.02	0.27	-1.21	1.19	235
Size	9.37	2.54	4.14	14.5	273
Δ *Size*	0.02	0.25	-1.6	1.1	235
Diver(USD)	0.12	0.15	0	0.84	273
Diver(USD RES)	0.03	0.05	0	0.36	273
Diver(All)	0.17	0.17	0	0.87	273
Diver(All RES)	0.04	0.06	0	0.41	265
Mismatch(5%)	0.19	0.39	0	1	273
Off BS	0.38	0.59	0	4.02	273

These summary statistics are for the complete sample over the period 1999-2015. This table presents variable averages, standard deviation, minimum and maximum. Variable definitions are provided in the appendix.

Table .4 – Summary statistics: commercial banks

Variable	Mean	Std. Dev.	Min.	Max.	N
Leverage	14.21	10.65	1.14	60.57	279
Δ *Leverage*	-0.01	0.23	-1.43	1.15	230
Size	7.81	2.86	2.76	14.39	279
Δ *Size*	0.03	0.18	-0.72	0.81	230
Diver(USD)	0.22	0.23	0	0.83	279
Diver(USD RES)	0.07	0.12	0	0.67	279
Diver(All)	0.28	0.27	0	0.88	279
Diver(All RES)	0.09	0.13	0	0.67	275
Mismatch(5%)	0.19	0.39	0	1	279
Off BS	0.2	0.32	0	2.68	279

These summary statistics are for the complete sample over the period 1999-2015. This table presents variable averages, standard deviation, minimum and maximum. Variable definitions are provided in the appendix.

Table .5 – Variance co-variance matrix (1999-2015)

	$\Delta Leverage$	$\Delta Asset$	$Diver.$	$Diver\_RES$	$Invest.$	$Mismatch$ (5%)
$\Delta Leverage$	1					
	465					
$\Delta Asset$	0.6324*	1				
	0					
	465	465				
$Divers$	-0.0283	-0.0542	1			
	0.5421	0.2437	0			
	465	465	552			
$Divers\_RES$	0.0667	0.0148	0.6230*	1		
	0.1512	0.7507	0			
	465	465	552	552		
$Invest.$	-0.0242	-0.0288	-0.2528*	-0.2243*	1	
	0.6023	0.5355	0	0		
	465	465	552	552	552	
$Mismatch$ (5%)	-0.0484	-0.0231	0.3680*	0.2185*	0.004	1
	0.2973	0.62	0	0	0.9248	
	465	465	552	552	552	552

Table .6 – Procyclical leverage and US dollar diversification

Dependent variable : $\Delta Leverage_t$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Leverage_{t-1}$	-0.03***	-0.04***	-0.04***	-0.04***	-0.04***	-0.05***	-0.06***	-0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
$\Delta Asset_t$	0.76***	0.74***	0.80***	0.79***	0.82***	0.72***	0.91***	0.82***
	(0.07)	(0.09)	(0.08)	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)
$\Delta Asset_t \times Divers_{t-1}$		0.06		0.12		0.65**		0.71*
		(0.26)		(0.28)		(0.29)		(0.40)
$Divers_{t-1}$		-0.10		-0.13		-0.03		-0.08
		(0.07)		(0.08)		(0.10)		(0.09)
$\Delta conso$	-0.04	-0.05	-0.03	-0.03	-0.16	-0.14*	-0.15	-0.14
	(0.08)	(0.07)	(0.09)	(0.08)	(0.10)	(0.08)	(0.10)	(0.10)
$\Delta Off\ BS$	0.00	0.00	0.01	0.00	-0.01	-0.03	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)	(0.03)
$\Delta IFRS$	0.08	0.07	0.10*	0.09	0.10	0.10	0.11	0.10
	(0.06)	(0.06)	(0.06)	(0.06)	(0.10)	(0.10)	(0.11)	(0.11)
$Constant$	0.07*	0.10*	0.09**	0.12*	0.13**	0.16***	0.18***	0.20***
	(0.04)	(0.05)	(0.04)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)
Adjusted R^2	0.45	0.46	0.50	0.51	0.57	0.58	0.63	0.64
N	433	433	385	385	213	213	192	192

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

Four samples are studied: (1) and (2) imply the unconstrained sample with all banks ; (3) and (4) include banks with a minimum of 5 years occurrence over the period ; (5) and (6) focus on investment banks ; (7) and (8) are for investment banks with a minimum of 5 years occurrence. Standard errors are clustered. LSDV include sub-category of banks and banks' nationality. Time Fixed-Effects included.

Table .7 – Procyclical leverage, US dollar diversification and pure valuation effect

Dependent variable : $\Delta Leverage_t$

	(1)	(2)	(3)	(4)
$Leverage_{t-1}$	-0.04***	-0.04***	-0.04***	-0.05***
	(0.01)	(0.01)	(0.02)	(0.02)
$\Delta Asset_t$	0.75***	0.80***	0.68***	0.78***
	(0.08)	(0.09)	(0.09)	(0.08)
$\Delta Asset_t \times Divers\_RES_{t-1}$	0.01	0.06	3.02***	3.15***
	(1.02)	(1.08)	(0.68)	(0.73)
$Divers\_RES_{t-1}$	-0.27	-0.31	0.08	-0.02
	(0.27)	(0.30)	(0.25)	(0.24)
$\Delta conso$	-0.04	-0.02	-0.15*	-0.15
	(0.07)	(0.08)	(0.07)	(0.09)
$\Delta Off\ BS$	0.00	0.00	-0.04*	-0.00
	(0.01)	(0.01)	(0.02)	(0.03)
$\Delta IFRS$	0.08	0.10*	0.12	0.12
	(0.06)	(0.06)	(0.10)	(0.11)
$Constant$	0.09	0.11*	0.15**	0.17**
	(0.06)	(0.06)	(0.06)	(0.07)
Adjusted R^2	0.46	0.52	0.59	0.65
N	433	385	213	192

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

Four samples are studied: (1) is the unconstrained sample with all banks ; (2) includes banks with a minimum of 5 years occurrence over the period ; (3) focuses on investment banks ; (4) is for investment banks with a minimum of 5 years occurrence. Standard errors are clustered. LSDV include sub-category of banks and banks' nationality. Time Fixed-Effects included.

Table .8 – Procyclical leverage and significant currency mismatch at 5%

Dependent variable : $\Delta Leverage_t$

	(1)	(2)	(3)	(4)
$Leverage_{t-1}$	-0.04***	-0.04***	-0.05***	-0.06***
	(0.01)	(0.01)	(0.01)	(0.02)
$\Delta Asset_t$	0.74***	0.79***	0.76***	0.88***
	(0.08)	(0.09)	(0.11)	(0.11)
$\Delta Asset_t \times Mismatch_{t-1}$	0.10	0.07	0.25*	0.15
	(0.12)	(0.13)	(0.13)	(0.14)
$Mismatch_{t-1}$	-0.04*	-0.04	-0.03	-0.03
	(0.03)	(0.03)	(0.02)	(0.03)
$\Delta conso$	-0.04	-0.03	-0.15*	-0.15
	(0.07)	(0.08)	(0.08)	(0.10)
$\Delta Off\ BS$	0.00	0.00	-0.02	0.01
	(0.01)	(0.01)	(0.02)	(0.04)
$\Delta IFRS$	0.08	0.10*	0.10	0.11
	(0.06)	(0.06)	(0.10)	(0.11)
$Constant$	0.09**	0.10**	0.16***	0.19***
	(0.04)	(0.05)	(0.06)	(0.06)
Adjusted R^2	0.46	0.51	0.57	0.63
N	433	385	213	192

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

Four samples are studied: (1) is the unconstrained sample with all banks ; (2) includes banks with a minimum of 5 years occurrence over the period ; (3) focuses on investment banks ; (4) is for investment banks with a minimum of 5 years occurrence. Standard errors are clustered. LSDV include sub-category of banks and banks' nationality. Time Fixed-Effects included.

Table .9 – Procyclical leverage, US dollar diversification relative to resident and crisis decomposition

Dependent variable : $\Delta Leverage_t$

	(1)	(2)	(3)	(4)
$Leverage_{t-1}$	-0.05***	-0.05***	-0.04**	-0.04*
	(0.01)	(0.02)	(0.02)	(0.02)
$Post\text{-}crisis \times Leverage_{t-1}$	-0.01	-0.02	-0.03	-0.05**
	(0.02)	(0.02)	(0.02)	(0.02)
$\Delta Asset_t$	0.70***	0.76***	0.64***	0.77***
	(0.11)	(0.12)	(0.13)	(0.12)
$Post\text{-}crisis \times \Delta Asset_t$	0.81***	0.79***	0.79***	0.78***
	(0.07)	(0.07)	(0.07)	(0.08)
$\Delta Asset_t \times Divers\_RES_{t-1}$	-0.19	-0.36	2.57***	2.74***
	(1.11)	(1.15)	(0.81)	(0.95)
$Post\text{-}crisis\ (\Delta Asset_t \times Divers\_RES_{t-1})$	2.92***	3.17***	4.14***	4.07***
	(1.02)	(0.96)	(0.73)	(0.72)
$Divers\_RES_{t-1}$	-0.28	-0.29	0.32	0.17
	(0.32)	(0.34)	(0.29)	(0.30)
$Post\text{-}crisis \times Divers\_RES_{t-1}$	-0.16	-0.19	-0.15	-0.08
	(0.13)	(0.14)	(0.30)	(0.30)
$Post\text{-}crisis\ dummy$	-0.07	-0.06	0.03	0.05
	(0.06)	(0.07)	(0.08)	(0.09)
$Constant$	0.10*	0.11*	0.08	0.10
	(0.05)	(0.06)	(0.07)	(0.08)
Adjusted R^2	0.47	0.52	0.60	0.65
N	433	385	213	192

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

Four samples are studied: (1) is the unconstrained sample with all banks ; (2) includes banks with a minimum of 5 years occurrence over the period ; (3) focuses on investment banks ; (4) is for investment banks with a minimum of 5 years occurrence. Standard errors are clustered. LSDV include sub-category of banks and banks' nationality. The table decomposes each coefficient relative to two sub-periods: the pre-crisis period from 1999 to 2007 and the post-crisis period from 2008 to 2015. There is no time FE. Not all control variables shown.

Table .10 – Procyclical leverage, US dollar diversification relative to resident and crisis decomposition (2008 and 2009 removed)

Dependent variable : $\Delta Leverage_t$

	(1)	(2)	(3)	(4)
$Leverage_{t-1}$	-0.05***	-0.05***	-0.04**	-0.05*
	(0.01)	(0.02)	(0.02)	(0.02)
$Post\text{-}crisis \times ln(Leverage_{t-1})$	0.01	0.01	-0.01	-0.02
	(0.02)	(0.02)	(0.03)	(0.03)
$\Delta Asset_t$	0.70***	0.76***	0.64***	0.77***
	(0.11)	(0.12)	(0.13)	(0.12)
$Post\text{-}crisis \times \Delta Asset_t$	0.83***	0.81***	0.81***	0.79***
	(0.09)	(0.10)	(0.10)	(0.10)
$\Delta Asset_t \times Divers\_RES_{t-1}$	-0.18	-0.38	2.51***	2.62**
	(1.12)	(1.15)	(0.82)	(0.95)
$Post\text{-}crisis\ (\Delta Asset_t \times Divers\_RES_{t-1})$	0.14	0.26	0.61	1.08
	(1.19)	(1.21)	(4.69)	(4.72)
$Divers\_RES_{t-1}$	-0.29	-0.30	0.28	0.13
	(0.32)	(0.34)	(0.29)	(0.30)
$Post\text{-}crisis \times Divers\_RES_{t-1}$	0.04	0.06	0.18	0.27
	(0.10)	(0.11)	(0.37)	(0.38)
$Post\text{-}crisis\ dummy$	-0.13*	-0.15*	-0.05	-0.03
	(0.07)	(0.08)	(0.09)	(0.10)
$Constant$	0.11**	0.12**	0.08	0.11
	(0.05)	(0.06)	(0.07)	(0.08)
Adjusted R^2	0.43	0.49	0.56	0.63
N	373	333	188	169

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

Four samples are studied: (1) is the unconstrained sample with all banks ; (2) includes banks with a minimum of 5 years occurrence over the period ; (3) focuses on investment banks ; (4) is for investment banks with a minimum of 5 years occurrence. Standard errors are clustered. LSDV include sub-category of banks and banks' nationality. The table decomposes each coefficient relative to two sub-periods: the pre-crisis period from 1999 to 2007 and the post-crisis period from 2010 to 2015. There is no time FE. Not all control variables shown.

Table .11 – Robustness checks

Dependant variable : : $\Delta Leverage_t$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Leverage_{t-1}$	-0.03	-0.05***	-0.05***	-0.05***	-0.05***	-0.04***	-0.05**	-0.03**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
$\Delta Asset_t$	0.72***	0.70***	0.66***	0.80***	0.76***	0.81***	0.68***	0.74***
	(0.16)	(0.11)	(0.11)	(0.14)	(0.11)	(0.11)	(0.10)	(0.09)
$\Delta Asset_t$ x $Divers_{t-1}$	-0.10	0.61*						
	(0.44)	(0.30)						
$Divers_{t-1}$	-0.12	-0.00						
	(0.09)	(0.10)						
$\Delta Asset_t$ x $Divers\_RES_{t-1}$			2.85***				3.06***	1.29*
			(0.68)				(0.69)	(0.65)
$Divers\_RES_{t-1}$			0.18				0.02	0.04
			(0.24)				(0.27)	(0.07)
$\Delta Asset_t$ x $Mismatch_{t-1}$				0.02	0.18	0.02		
				(0.16)	(0.13)	(0.20)		
$Mismatch_{t-1}$				0.03	0.02	0.00		
				(0.03)	(0.02)	(0.03)		
$Constant$	0.09	0.16**	0.14**	0.14**	0.14**	0.14**	0.15**	0.10**
	(0.09)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)
Adjusted R^2	0.31	0.58	0.57	0.57	0.57	0.56	0.58	0.59
N	220	213	207	213	213	213	172	258

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

(1) includes commercial banks and USD diversification. Column (2) to column (8) focus on investment banks. In (2) and (3), we replace USD diversification with total foreign currency diversification. (4) (5) and (6) introduce a mismatch ratio at 1%, 2.5% and 7.5% of total assets respectively. Definition of investment banks is changed in (7) and (8). In (7) we use the 40% value of the deposit ratio instead of the median, while in (8) we use the 60 % threshold. Standard errors are clustered. Not all control variables are reported in table 11 ($Conso$, $Off\ BS$,$IFRS$, Time FE, sub-category of banks and banks' nationality).

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