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Banking Leverage with Currency Diversification

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Banking leverage with currency diversification.

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ABSTRACT:

The brutal adjustments of global banks' balance sheet regarding economic activity have rekindled discussions about the procyclicality of the banking leverage. During economic bursts, the collateral value of banks decreases and their risk-taking capacity is reduced. Banks raise less funds and their leverage - defined as total asset over equity - goes down: the leverage is pro-cyclical. The paper investigates the procyclicality of bank leverage when banks can borrow and invest in two different currencies, as it is the case especially for European banks. To the extent that shocks are asymmetric, we find that currency diversification may reduce the procyclicality of the leverage and that floating exchange rate increases the risk-taking capacity of banks.

JEL classification: F3, F4, G15

Keywords: procyclical leverage, global banks, currency diversification, collateral.

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1 Introduction

The procyclicality of bank leverage is related to models of financial accelerators developed by Bernanke and Gertler [1989] and Kiyotaki and Moore [1997]. Financial distress, characterized by large declines in asset prices, deteriorate banks' net worth and increase their funding costs. It results from this an endogenous process which is a major factor of depressed economic activity.

The pre-crisis banking development followed by the crisis downturn have recently brought researchers' attention to bank leverage adjustments. As developed by Adrian and Shin [2013], the leverage of banks, which is defined as the ratio of total assets to equity, is procyclical: it goes up in good times and shrinks in downturns. This procyclicality comes from two specifications. First, banks' balance sheets are marked to market. Thus, an improvement of the economic activity increases their net worth. Second, banks are active in the management of their balance sheet: their equity staying constant they reallocate the increase of their net worth in additional borrowing and investment. The leverage therefore increases. Figure 1 illustrates balance sheet adjustment following an improvement of economic activity.

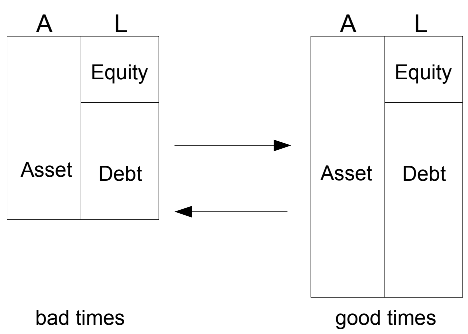
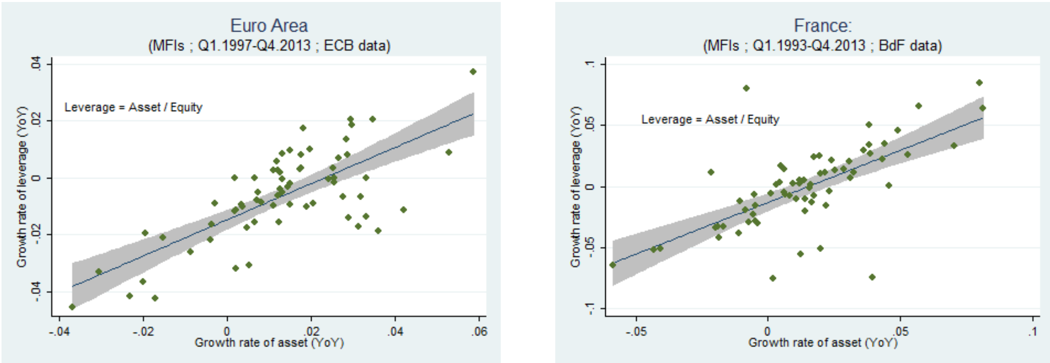


Figure 1: Pro-cyclical leverage - Adrian and Shin (2013)



(a) Banks located in the euro area

(b) Banks located in the euro area

Figure 2: Procyclical leverage of banks, aggregate data.

As banks are active in the management of their balance sheet, they behavior is compatible with a Value at Risk (VaR) rule. Adrian and Shin [2013] build a micro-founded model which links the leverage to the VaR rule. Banks adjust their balance sheet to maintain a given probability of failure.

Empirically, Adrian and Shin [2008], Gropp and Heider [2009], Kalemli-Ozcan et al. [2011], Baglioni et al. [2013] study the determinants of the leverage and its alleged procyclicality. Only Gropp and Heider [2009] invalidate this relationship.[2] In the other papers, leverage is found pro-cyclical especially for investment banks. Figure 2 supports this conclusion by plotting the growth rate of leverage along the growth rate of total assets. For both banks located in the euro area (a) and banks located in France (b) the correlation is positive and significant.

Although the literature mostly concludes to a procyclical leverage, it also highlights the potential differences across geographic locations. According to Kalemli-Ozcan et al. [2011] European investment banks may display a less procyclical leverage compared to the US ones. The heterogeneity across banks may reflect different composition of banks'

[2]In Gropp and Heider [2009], banks leverage converges to a bank-specific target

balance sheets. As banks use their collateral to raise funds to finance their investment, the composition of their collateral is a driving force in the leverage procyclicality. One major issue in this respect may be the currency denomination of the assets, which has not been incorporated in theoretical and empirical analyses on leverage procyclicality.

Adrian and Shin [2013] use a contracting model between a representative bank and its creditor which links the leverage to the domestic state of nature. Their model micro-founds the VaR Rule but excludes any currency diversification. More recently, Bruno and Shin [2015] introduce a cross-border network with a global bank, a regional bank and a local corporate. Both the global and the regional bank make their financial operations in foreign currency. On the contrary, the local corporate invests in local currency and raises debt from the regional bank in foreign currency. Thus, the risk regarding exchange rate fluctuations is only borne by the local corporate and currency diversification is excluded in banks' balance sheets.

Since the early 2000s, banks have largely diversified both sides of their balance sheets. Figure 3 breakdowns the currency of denomination of external banking positions based on BIS Data. On both sides of the balance sheet, the US dollar and the euro are the two major currencies used by reporting banks. This diversification is related to the banks' international strategy as highlighted by Baba et al. [2009], Borio and Disyatat [2011], Shin [2012], McGuire and Von Peter [2012].

Because they affect the value of banks' collateral, exchange rate variations should be incorporated in the analysis of leverage dynamics. The purpose of this paper is to build a theoretical model which allows for currency diversification of both the assets and the liabilities of a bank. I extend Adrian and Shin [2013] model through introducing a second currency of denomination on both sides of the balance sheet. The bank can

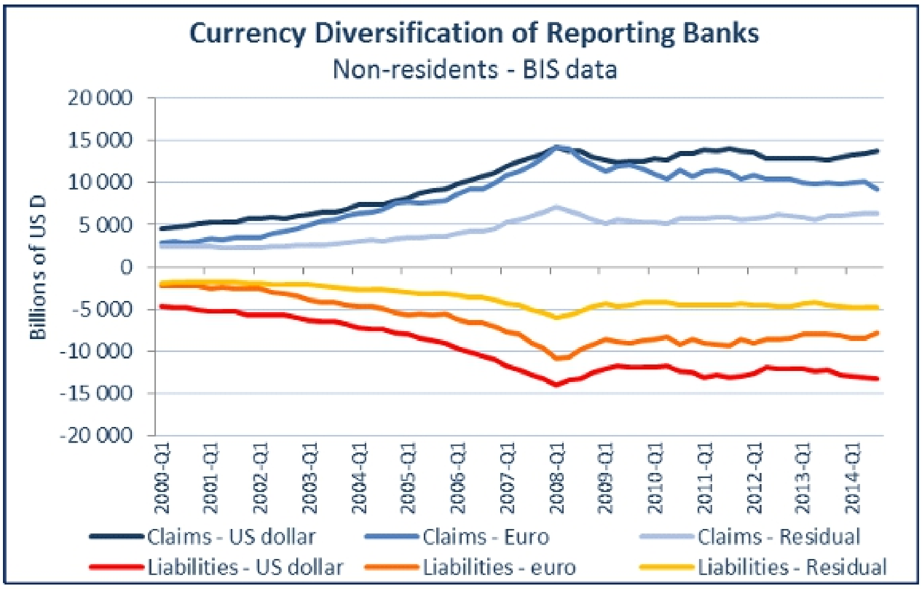


Figure 3: Currency breakdown of total reporting banks. International positions. BIS.

borrow and invest in two different currencies: a domestic currency which is the currency of bank's equity, and a foreign currency. The bank's balance sheet is expressed in domestic currency which implies a conversion of foreign asset and liability. Two exchange rate regimes are successively studied: a fixed regime and a floating regime, where the exchange rate depends on the relative state of nature in the two issuing countries.[3]

One important result from Adrian and Shin [2013] is the VaR rule. As banks follow a VaR rule, they adjust their balance sheet in order to maintain a constant probability of default. Introducing currency diversification does not affect the VaR rule or the mechanism which brings to the VaR rule. However, depending on the type of shocks and on the exchange rate regime, the balance sheet adjustment would be affected by the degree of currency diversification. Three specific types of shocks are studied here: (i) a symmetric shock that does not affect the exchange rate; (ii) an anti-asymmetric

[3]Contrasting with to Bruno and Shin [2015], the exchange rate here is directly linked to the relative state of nature.

shock where the domestic economy is positively impacted while the foreign economy is negatively impacted; (iii) and an asymmetric shock whereby both economics are affected in the same direction but one of them is more affected than the other.

A positive shock in the home country induced upward reaction the leverage. If the shock is symmetric, currency diversification of the balance sheet does not modify the extent of the leverage procyclical reaction whatever the exchange rate regime. If the shock is anti-asymmetric, the risk incurred on foreign assets induces downward adjustment of leverage although it is less the case when the foreign currency depreciates. Finally, if the shock is asymmetric, procyclicality is also diminished with currency diversification.

The rest of the paper is organized as follows. Section 2 introduces the currency diversification in the Adrian and Shin [2013] framework. Section 3 develops the utility functions of agents. Two main constraints are derived from utility maximization. Section 4 defines the VaR rule and the reaction of leverage to three economic shocks. Section 5 concludes and provides some policy implications.

2 Currency diversification

The model is based on a representative bank's balance sheet. The bank invests in assets and raises funds from its creditors. There are two currencies of denomination for assets and debts, corresponding to two different countries. The economic states of nature corresponding to each economy are known publicly and determine the distribution of asset returns.

There are two periods T=0,1. Knowing the state of nature and the distribution of returns, the bank and the creditors agree on the amount to be reimbursed at T=1 in order to satisfy the VaR rule. Then, this amount defines the level of debt the bank is able to raise at T=0.

2.1 The accounting framework

The first agent in this model is a representative bank which is similar to a European investment bank. It is domestic in the sense that its equity and its balance sheet are in domestic currency. The domestic currency (e.g the euro) is the first currency. The bank is risk neutral and equity E is exogenous.[4] The second agent is the creditor of the bank who can be seen as a Money Market Fund or another investment bank. The creditor lends money to the bank in both currencies. The creditor is also risk neutral. The exchange rate S is defined as the number of domestic units per unit of foreign currency.

At T=0, the bank raises funds backed by collateral in domestic and foreign currency (A and $A^\star$, respectively). Total asset expressed in domestic currency is equal to $A + SA^\star$. We note a the share of assets in domestic currency and $(1 - a)$ the share of assets in foreign currency. a will vary depending on S.[5] Funds are in domestic and in foreign currency (D and $D^\star$, respectively). Thus, total funding from creditors expressed in domestic currency is equal to $D + SD^\star$.

At T=1, the bank receives a total expected return from its investments $a(1+\bar{r})+(1-a)(1 + \bar{r}^\star)$, where $\bar{r}$ and $\bar{r}^\star$ are the expected returns from the domestic and the foreign asset, respectively. Returns depend on the state of nature specific to each currency area, θ and $\theta^\star$, respectively. θ and $\theta^\star$ are known publicly since T=0 and they do not change between the two periods.

At T=1, the bank reimburses its domestic and foreign creditors with respectively $\bar{D}$ and $S\bar{D}^\star$. As θ and $\theta^\star$ are known for the two periods, there is no macroeconomic

[4] An exogenous equity is in line with the theory of pro-cyclical leverage developed by Shin.

[5] See section 4.

risk. However, the creditor of the bank faces a risk of default regarding the repayment at T=1. The risk of default depends on the investment choice made by the bank. It is assumed that $\bar{D} > D$ and $S\bar{D}^\star > SD^\star$ to remunerate the default risk. At T=0, the creditor receives a defaultable debt claim which enters in his/her utility function.

The bank's balance sheets at each period are given in table 1.

T=0, at market value:

Assets	Liabilities
A	E
$SA^\star$	D
	$SD^\star$

T=1, at notional value:

Assets	Liabilities
$(1+\bar{r})A$	$\bar{E}$
$(1+\bar{r}^\star)SA^\star$	$\bar{D}$
	$S\bar{D}^\star$

Table 1: Bank's balance sheet at T=0 and T=1

2.2 Leverage

Four debt ratios are defined relative to each funding currency and each period. The debt ratios at T=0 are:

$$d = \frac{D}{(A + SA^\star)} \quad \text{and} \quad d^\star = \frac{SD^\star}{(A + SA^\star)} \tag{1}$$

The corresponding notional value of debt ratios at T=1 are:

$$\bar{d} = \frac{\bar{D}}{(A + SA^\star)} \quad \text{and} \quad \bar{d}^\star = \frac{S\bar{D}^\star}{(A + SA^\star)} \tag{2}$$

$\bar{E}$ is the equity at the notional value. It is equivalent to the equity at market value at T=0 augmented with interests. In other words, $E < \bar{E}$ and $a(1+\bar{r}) + (1-a)(1+\bar{r}^\star) > (\bar{d} + \bar{d}^\star)$.

The leverage λ is defined as the ratio the total assets to equity, at market value:

$$\lambda = \frac{(A + SA^{\star})}{E} = \frac{(A + SA^{\star})}{(A + SA^{\star}) - (D + SD^{\star})} = \frac{1}{1 - (d + d^{\star})} \tag{3}$$

2.3 Investment strategy

The bank makes an indivisible choice between two types of portfolios. Each portfolio is made of an asset in domestic currency and an asset in foreign currency. The weight of each type of assets is introduced with a and $(1 - a)$. The portfolio's distribution comes from a mixture distribution of the two asset return distributions. As each asset return follows a GEV distribution, the portfolio's return is also defined by a General Extrem Value (GEV) distribution. The first portfolio is a good portfolio with a total expected return of $[ar_H + (1 - a)r_{H^{\star}}]$, where r_H denotes the return of the good home asset and $r_{H^{\star}}$ the return of the good foreign asset. The second portfolio is a less good portfolio compared to the latter. Its total expected return $[ar_L + (1 - a)r_{L^{\star}}]$ is reduced through a parameter k (e.g $k > 0$) and it includes more volatility through a parameter m (e.g $m > 1$).[6] The cumulative distribution of the good asset in domestic currency, the cumulative distribution of the good asset in foreign currency, the cumulative distribution of the bad asset in domestic currency, and the cumulative distribution of the bad asset in foreign currency are the following, where θ, σ and ξ are respectively the location parameter, the scale parameter, and the shape parameter, while z is the *iid* random variable:

[6]The introduction of an investment choice enable a contract model between the creditor and the bank such as Holmström and Tirole [1997].

$$F_H(z) = exp\left\{-\left(1+\xi\left(\frac{z-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}$$

$$F_{H^\star}(z) = exp\left\{-\left(1+\xi\left(\frac{z-\theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}$$

$$F_L(z) = exp\left\{-\left(1+\xi\left(\frac{z-(\theta-k)}{\sigma m}\right)\right)^{-\frac{1}{\xi}}\right\}$$

$$F_{L^\star}(z) = exp\left\{-\left(1+\xi\left(\frac{z-(\theta^\star-k)}{\sigma m}\right)\right)^{-\frac{1}{\xi}}\right\}$$

Using a mixture distribution, the cumulative distribution function of total return when the bank invests in the good portfolio is : [7]

$$F_{H,H^\star}(z) = a\ exp\left\{-\left(1+\xi\left(\frac{z-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} + (1-a)\ exp\left\{-\left(1+\xi\left(\frac{z-\theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} \tag{4}$$

If the bank invests in the bad portfolio, the cumulative distribution function is defined by:

$$F_{L,L^\star}(z) = a\ exp\left\{-\left(1+\xi\left(\frac{z-(\theta-k)}{\sigma m}\right)\right)^{-\frac{1}{\xi}}\right\} + (1-a)\ exp\left\{-\left(1+\xi\left(\frac{z-(\theta^\star-k)}{\sigma m}\right)\right)^{-\frac{1}{\xi}}\right\}$$

Thus, the total expected return of the portfolio depends on the type of shock the global economy faces (e.g θ and $\theta^\star$).

The cumulative distribution function allows to define the probability of default α when the bank invests in the good portfolio. This risk of default appears if the realized total return is below a given level that is equal to the total debt ratio at the notional

[7] This new framework that uses a mixture distribution is still compatible with a Second Order Stochastic Dominance as in the referring model.

value. Thus, the probability of default α is defined by the cumulative distribution function such as:

$$\begin{aligned}\alpha &= F_{H,H^\star}(\bar{d}+\bar{d}^\star)\\ &= a\ exp\left\{-\left(1+\xi\left(\frac{(\bar{d}+\bar{d}^\star)-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} + (1-a)\ exp\left\{-\left(1+\xi\left(\frac{(\bar{d}+\bar{d}^\star)-\theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}\end{aligned} \tag{5}$$

Since the creditor is uninsured, he/she holds a defaultable debt claim in return to the funds they lent to the bank at T=0. This claim will enter the utility because it is part of the wealth at T=0. The value of this defaultable debt claim can be divided into two components known as cash $(\bar{D}+S\bar{D}^\star)$ and a short position on a put option π (Merton [1974]). Since the risk differs between the two types of portfolios, the put option is specific to each investment choice.

If the bank invests in the good portfolio, I obtain the following put option price:[8]

$$\pi_{H,H^\star}\bar{D}+S.\bar{D}^\star, A+SA^\star) = (A+SA^\star).\pi_{H,H^\star}(\bar{d}+\bar{d}^\star,1) \equiv (A+SA^\star).\pi_{H,H^\star}(\bar{d}+\bar{d}^\star)$$

If the bank invests in the bad portfolio, the price of the put option is:

$$\pi_{L,L^\star}(\bar{D}+S.\bar{D}^\star, A+SA^\star) = (A+SA^\star).\pi_{L,L^\star}(\bar{d}+\bar{d}^\star,1) \equiv (A+SA^\star).\pi_{L,L^\star}(\bar{d}+\bar{d}^\star)$$

[8]The price of the put option depends on the total amount reimbursed at the end of the period - $\bar{D}+S.\bar{D}^\star$ - and on the total value of asset $A+SA^\star$.

3 Agents' participation constraints:

3.1 Creditor's incentive constraint

The creditor of the bank is risk neutral. He maximizes its total net expected payoff.

If the bank invests in the good portfolio, the net expected payoff is the following:

$$\begin{aligned} U^{c+c^\star}_{H,H^\star}(A+SA^\star) &= (\bar{D}+S\bar{D}^\star) - (A+SA^\star)\pi_{H,H^\star}(\bar{d}+\bar{d}^\star) - (D+SD^\star) \\ &= (A+SA^\star)\left[(\bar{d}+\bar{d}^\star) - \pi_{H,H^\star}(\bar{d}+\bar{d}^\star) - (d+d^\star)\right] \end{aligned} \tag{6}$$

The requirement that utility is equal or higher than 0 provides the first participation constraint (PC):

$$0 \le (\bar{d}+\bar{d}^\star) - \pi_{H,H^\star}(\bar{d}+\bar{d}^\star) - (d+d^\star) \tag{7}$$

$$(d+d^\star) = (\bar{d}+\bar{d}^\star) - \pi_{H,H^\star}(\bar{d}+\bar{d}^\star) \tag{PC}$$

Similarly for an investment in the less good portfolio:

$$\begin{aligned} U^{c+c^\star}_{L,L^\star}(A+SA^\star) &= (A+SA^\star)\left[(\bar{d}+\bar{d}^\star) - \pi_{L,L^\star}(\bar{d}+\bar{d}^\star) - (d+d^\star)\right] \\ (d+d^\star) &= (\bar{d}+\bar{d}^\star) - \pi_{L,L^\star}(\bar{d}+\bar{d}^\star) \end{aligned} \tag{8}$$

The PC constraints define the total debt ratio at the market value relative to the total debt ratio at the notional value. The latter should be large enough to make an incentive for the creditor to participate. The more the bank offers large reimbursement, the more the creditor is tempted to lend money at T=0. Under this form, it does not depend directly on the portfolios return specifications.

3.2 Bank's incentive constraint:

As the bank is risk neutral, it also maximizes its total net expected payoff. The introduction of a second investment currency changes the composition of the bank's net expected payoff $U^B_{H,H^\star}$. In this framework, returns come from both assets in domestic and in foreign currency. Thus the net expected payoff when the bank invests in the good portfolio is equal to:

$$\begin{aligned} U^B_{H,H^\star} &= A.r_H + SA^\star r_{H^\star} + (D + S.D^\star) - (\bar{D} + S.\bar{D}^\star) + (A + SA^\star).\pi_{H,H^\star}(\bar{d} + \bar{d}^\star) \\ &= (A + SA^\star)\left[a.r_H + (1-a)r_{H^\star} + (d + d^\star) - (\bar{d} + \bar{d}^\star) + \pi_{H,H^\star}(\bar{d} + \bar{d}^\star)\right] \end{aligned} \tag{9}$$

When the bank invests in the bad portfolio the net expected payoff is equal to:

$$\begin{aligned} U^B_{L,L^\star} &= A.r_L + SA^\star r_{L^\star} + (D + S.D^\star) - (\bar{D} + S.\bar{D}^\star) + (A + SA^\star).\pi_{L,L^\star}(\bar{d} + \bar{d}^\star) \\ &= (A + SA^\star)\left[a.r_L + (1-a)r_{L^\star} + (d + d^\star) - (\bar{d} + \bar{d}^\star) + \pi_{L,L^\star}(\bar{d} + \bar{d}^\star)\right] \end{aligned} \tag{10}$$

Assuming that $U^B_{H,H^\star} \geq U^B_{L,L^\star}$ we get the incentive constraint IC:

$$a(r_H - r_L) + (1-a)(r_{H^\star} - r_{L^\star}) \geq \pi_{L,L^\star}(\bar{d} + \bar{d}^\star) - \pi_{H,H^\star}(\bar{d} + \bar{d}^\star) \tag{11}$$

$$\text{Where :}\ (r_H - r_L) = (r_{H^\star} - r_{L^\star})$$

$$r_H - r_L \geq \Delta\pi(\bar{d} + \bar{d}^\star)$$

$$r_H - r_L = \Delta\pi(\bar{d} + \bar{d}^\star) \tag{IC}$$

The spread between the good ad the less good asset are the same for the domestic and the foreign assets. in returns for each currency of denomination are similar. Thus, the left hand side (lhs) of the IC constraint can be simplified as if the bank only hold assets in the domestic currency.[9]

[9] See the appendix.

The IC constraint stipulates that for any economic condition there is a solution $(\bar{d} + \bar{d}^{\star})$ that satisfies this identity. The unique solution illustrated in figure 4 comes from the Second Order Stochastic Dominance (SOSD) between the two mixture distributions and the differential in volatility. $\pi(z)$ increases until $F_{H,H^{\star}}(z) = F_{H,H^{\star}}(z)$ and decreases after the junction. As shareholders receive returns, $(\bar{d} + \bar{d}^{\star}) < (1 + \bar{r})$, there is a unique solution $(\bar{d} + \bar{d}^{\star})$ which satisfies the IC constraint.

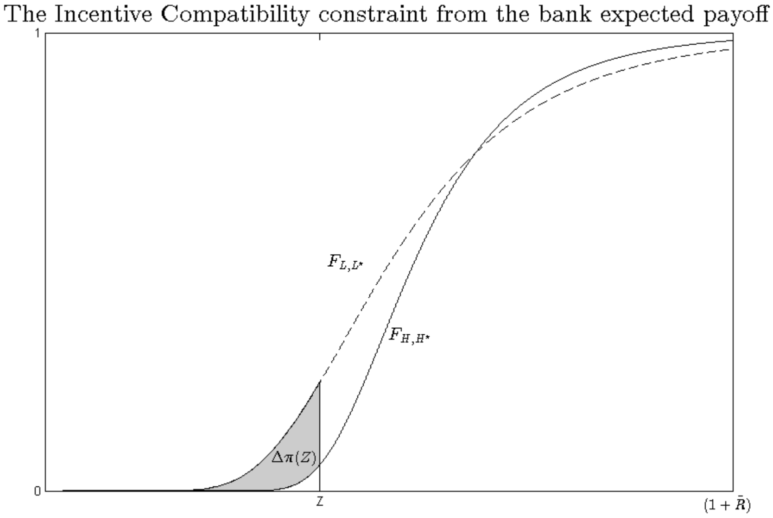


Figure 4: A unique solution to satisfy the IC constraint

As in Adrian and Shin [2013], the IC constraint also represents the moral hazard trade-off from Holmström and Tirole [1997]. The lhs represents the bank's private benefit of investing in the good portfolio while the right hand side (rhs) is equal to private benefit of investing in the bad portfolio (e.g low effort in the moral hazard model of Holmström and Tirole [1997]). Associated with the PC constraint from the creditor, the bank is constrained to invest in the good portfolio where put option induces lower prices.

However, under this form it is difficult to have a clear definition of $(\bar{d}+\bar{d}^\star)$. Additional assumptions are needed to have a closed form solution.

3.3 Value at Risk

As in Adrian and Shin [2013], it is supposed here that $\xi = -1$ and $m \mapsto 1$.[10] Thus, the cumulative distribution functions of the mixture functions are of the form:

$$
\begin{aligned}
F_{H,H^\star}(z) &= a\ exp\left\{\frac{z-\theta}{\sigma} - 1\right\} + (1-a)\ exp\left\{\frac{z-\theta^\star}{\sigma} - 1\right\} \\
F_{L,L^\star}(z) &= a\ exp\left\{\frac{z-(\theta-k)}{\sigma} - 1\right\} + (1-a)\ exp\left\{\frac{z-(\theta^\star-k)}{\sigma} - 1\right\}
\end{aligned}
$$

Hence $F_{L,L^\star} = e^{\frac{k}{\sigma}} F_{H,H^\star}$

These assumptions allow to simplify the rhs of IC as follows[11]

$$
\begin{aligned}
(r_H - r_L) &= \Delta\pi(\bar{d} + \bar{d}^\star) \\
&= (e^{\frac{k}{\sigma}} - 1)\sigma F_{H,H^\star}(\bar{d} + \bar{d}^\star) \qquad (12)
\end{aligned}
$$

Because $F_{H,H^\star}$ is the probability of default of the bank when it invests in the good portfolio, I can extract the following VaR rule:

$$
\alpha = F_{H,H^\star}(\bar{d} + \bar{d}^\star) = \frac{(r_H - r_L)}{(e^{k/\sigma} - 1)\sigma} \qquad (13)
$$

As the rhs of (13) does not depend on θ or $\theta^\star$, the VaR rule holds and the probability of default α is maintained at the same level for any state of nature and any level of diversification. The bank adjusts its total debt ratio at T=1 in order to satisfy this identity.[12]

[10] $\xi = -1$ implies a bounded distribution function on the right side. As the VaR rule focuses on the left side of the distribution, this assumption is not a problem. $m \mapsto 1$ makes the volatility between the good and the bad asset comparable. It allows an approximation of a closed form solution.

[11] See the appendix.

[12] In a situation where the bank faces a positive shock and does not adjust its total debt ratio at T=1, the probability of default declines. On the one hand, the bank receives more return, but on the other hand, the bank does not reimburse more. To satisfy the VaR rule, the bank revises the debt ratio

It is important to notice that the VaR rule focuses on the tail of the distribution. If the tail is thickened by changes in the state of nature, the bank has to decrease its total debt ratio in order to maintain α.

Equation (13) is equivalent to:[13]

$$\alpha = aF_{H^\star} + (1-a)F_{H^\star} = \frac{(r_H - r_L)}{(e^{k/\sigma} - 1)\sigma} \tag{14}$$

Hence:

$$\alpha = exp\left\{\frac{(\bar{d}+\bar{d}^\star) - \theta}{\sigma} - 1\right\}\left[a + (1-a)exp\left\{\frac{\theta - \theta^\star}{\sigma}\right\}\right] = \frac{(r_H - r_L)}{(e^{k/\sigma} - 1)\sigma} \tag{15}$$

The VaR rule constrains the bank in its adjustment to the states of nature. The adjustment of $(\bar{d}+\bar{d}^\star)$ to the state of nature is:

$$(\bar{d}+\bar{d}^\star) = \theta + \sigma + \sigma ln\left(\frac{(r_H - r_L)}{(e^{k/\sigma} - 1)\sigma}\right) - \sigma ln\left(a + (1-a)\ exp\left\{\frac{\theta - \theta^\star)}{\sigma}\right\}\right) \tag{16}$$

The definition of the total debt ratio at the notional value is given by (16). If $a = 1$, there is no currency diversification and $(\bar{d}+\bar{d}^\star)$ depends on the domestic state of nature. On the contrary, if $a = 0$, only the foreign state of nature affects $(\bar{d}+\bar{d}^\star)$. The procyclicality of the leverage is derived from the degree of total debt ratio adjustment regarding an economic shocks.

Proposition 1 *Currency diversification does not affect the VaR rule. The bank adjusts its balance sheet to the state of nature in both currency areas.*

upwards.

[13] I use the following arrangement: $F_{H^\star} = F_H \,.\, exp\left\{\frac{\theta-\theta^\star}{\sigma}\right\}$

4 Procyclical leverage with currency diversification

4.1 Economic shocks and exchange rate fluctuations:

As in Adrian and Shin [2013] return depends on the state of nature and on a function of the shape parameter $H(\xi)$.

The two economies in the model are assumed to be developed and similar, with a perfect capital mobility. In a floating regime, the exchange rate S is determined based on the Uncovered Interest Rate Parity.[14]

Hypothesis 1 *The definition of S follows the Uncovered Interest Rate Parity.*

$$S = 1 + \frac{r_{H^\star} - r_H}{1 + r_H} \tag{17}$$

Where :

$$\begin{aligned} r_{H^\star} =& \theta^\star + \sigma H(\xi) \\ r_H =& \theta + \sigma H(\xi) \end{aligned}$$

As θ and $\theta^\star$ are known for the two periods, the exchange rate does not change between T=0 and T=1. Starting from an initial situation T<0 where $\theta = \theta^\star$, a symmetric increase in θ and $\theta^\star$ in both economies does not change the interest rate spread. The exchange rate is maintained at it initial value $S = 1$. Now, if the amplitude of a positive shock is larger in the domestic economy, the domestic currency appreciates and S decreases. Because the domestic currency appreciates, the converted value of the foreign asset declines, which leads to a larger share of domestic asset relative to total asset: *a*

[14] The definition of S supposes that shocks are temporary.

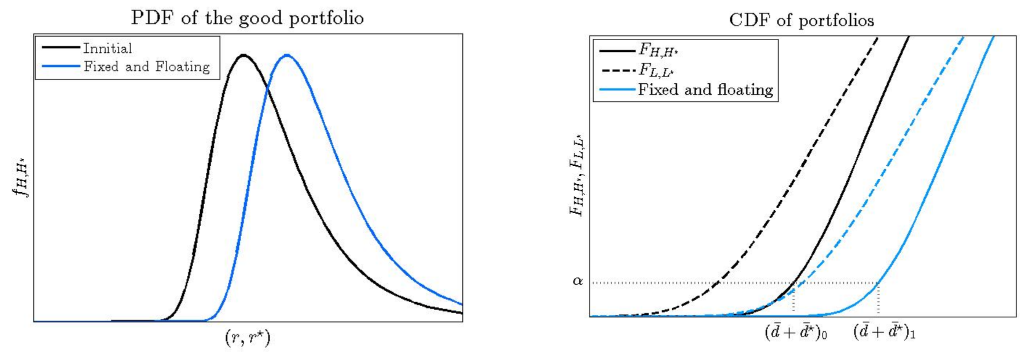
goes up. Finally, an anti-asymmetric shock such that θ and $\theta^\star$ move in opposit directions by the same amount adds to the depreciation of the foreign currency. S falls below unity and the rise in a is more pronounced.

Implicitly, we assume that the bank does not change the composition of its portfolio regardless of the shock. Consequently, the changes in a and $(1-a)$ only reflect the exchange rate effect on converted value. It allows to clearly distinguish the impact of currency diversification on leverage.

Hypothesis 2 *Changes in a and $(1-a)$ only reflects the exchange rate fluctuations.*

4.2 A symmetric, positive shock:

If the two economies face a common positive shock, currency diversification does not affect the pro-cyclicality of the leverage. Assets still offer a similar return and the exchange rate does not fluctuate. As illustrated in figure 5.a), the PDF of the good portfolio total return shifts to the right. As total expected return goes up, the bank has to increase its total debt ratio $(\bar{d}+\bar{d}^\star)$ to maintain α constant. The total debt ratio at the notional value goes from $(\bar{d}+\bar{d}^\star)_0$ to $(\bar{d}+\bar{d}^\star)_1$ in figure 5.b).



(a) Total portfolio return increases

(b) Leverage goes up to satisfy the VaR rule

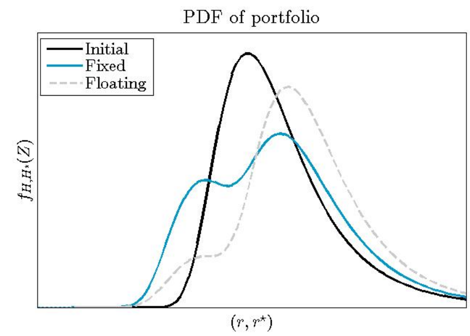
Figure 5: Global and positive shock: currency diversification does not affect the leverage procyclicality

Proposition 2 *Whatever the exchange-rate regime, currency diversification does not affect the leverage procyclicality when shocks are symmetric.*

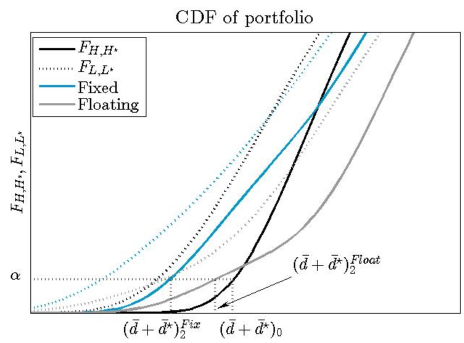
4.3 An anti-asymmetric shock:

The anti-asymmetric shock is characterized by a positive shock domestically and an opposite shock in the foreign economy. The foreign asset is subject to increased risk of loss. As illustrated in blue in figure 6.a), the portfolio's PDF in a fixed exchange rate regimes now contains two modes, one relative to each asset. As the portfolio held by the bank becomes riskier, the bank has to deleverage to satisfy the VaR rule and the constant probability of default α. Figure 6.b) shows this new adjustment where $(\bar{d}+\bar{d}^{\star})$ goes from $(\bar{d}+\bar{d}^{\star})_0$ to $(\bar{d}+\bar{d}^{\star})_2^{Fix}$.

With an anti-asymmetric shock the appreciation of the domestic currency is clearly visible. Therefore, the weight of domestic asset increases and the density relative to its mode goes up as illustrated in grey in 6.a). As the risk of loss decreases, the portfolio becomes less risky compared to the fixed exchange rate regime. The bank still deleverages to satisfy the VaR rule and α, but the adjustment is less brutal. Total debt ratio moves to $(\bar{d}+\bar{d}^{\star})_2^{Float}$.



(a) Risks in portfolio increases



(b) Leverage still goes down to satisfy the VaR rule

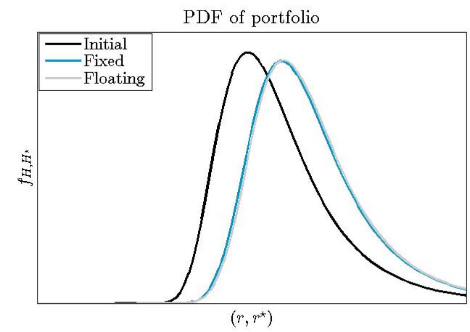
Figure 6: Anti-asymmetric shock: a counter-cyclical shock

Proposition 3 *In both exchange rate regimes, an anti-asymmetric shock leads to a counter-cyclical leverage when there is currency diversification.*

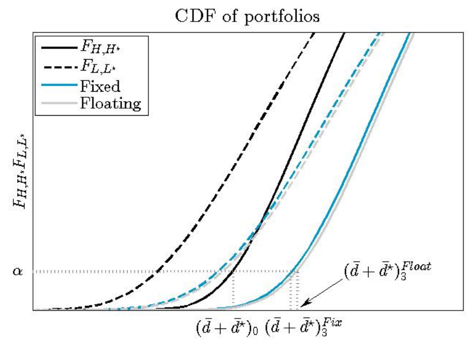
4.4 An asymmetric and positive shock:

This last shock is positive but the amplitude of the shock is lower in the foreign economy. Thus, the return of assets differs and the distribution of the portfolio return flattens when the exchange rate is fixed. As illustrated in figure 6, the blue PDF of the portfolio still shifts to the right but the density relative to the mode decreases. Consequently, the bank still increases $(\bar{d} + \bar{d}^{\star})$ but to a lesser extent than in the symmetric case. It reaches $(\bar{d} + \bar{d}^{\star})_3^{Fix}$ to keep α constant in 7.b).

In a floating regime, the procyclicality increases compared to the fixed one. The asymmetric shock leads to an appreciation of the domestic currency. As the converted value of the foreign asset decreases, the domestic asset weight in the portfolio increases. In figure 7.a) the grey PDF moves slightly to the right compared to the fixed exchange rate regime. Thus, the bank leverage has to be more procyclical to satisfy the VaR rule and the constant α in figure 7.b). Total debt ratio rises from $(\bar{d} + \bar{d}^{\star})_0$ to $(\bar{d} + \bar{d}^{\star})_3^{Float}$.



(a) Total portfolio return increases less



(b) Leverage still goes up to satisfy the VaR rule

Figure 7: Asymmetric and positive shock: currency diversification reduces leverage procyclicality

Regarding the last two economic shocks, a floating exchange rate regime always promotes the asset which offers a better return. As the bank follows a VaR rule, the floating exchange rate regime increases its capacity to raise funds.

Proposition 4 *The introduction of a floating exchange rate increases the funds raising capacity of the banks when shocks are anti-asymmetric or asymmetric.*

Conclusion

Global banks have global strategies regarding the composition of their assets and liabilities. A significant part of their balance sheet is diversified across regions. According to the empirical literature, this diversification may have an impact on the leverage procyclicality. However, this does not account for currency diversification which may affect the converted value of foreign assets in the balance sheet.

This paper offers a first theoretical model which introduces currency diversification in global banks' balance sheet. Based on Adrian and Shin [2013], the model microfounds the VaR rule and confirms the active behavior of banks in response to economic shocks. Then, depending on the type of shocks and on the exchange rate regime, the introduction of currency diversification affects leverage adjustment. When shocks are asymmetric, leverage procycliclality can be reduced if foreign asset returns are less unstable than domestic ones to global financial cycle. When shocks are anti-asymmetric, the leverage becomes counter-cyclical in both exchange rate regimes. When shocks are not correlated, the floating exchange rate regime promotes the asset which offers a better return. As the bank follows a VaR rule, the floating exchange rate regime increases its risk-taking capacity.

Two 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, regulators could encourage diversification with assets less correlated to the global financial cycle. This would reduce the leverage procyclicality whatever the exchange-rate regime.

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5 Appendix

.1 Constant spreads:

As assets only differ in their location parameters, the spreads in interest rate are equal and constant relative to the economic condition.

$$\begin{aligned}
& a(r_H - r_L) + (1-a)(r_{H^\star} - r_{L^\star}) \\
& = a.\left(\theta + \sigma H(\xi) - (\theta - k) - m\sigma H(\xi)\right) + (1-a)\left(\theta^\star + \sigma H(\xi) - (\theta^\star - k) - m\sigma H(\xi)\right) \\
& = a.\left(k - \sigma(m-1)H(\xi)\right) + (1-a)\left(k - \sigma(m-1)H(\xi)\right) \\
& = \left(k - \sigma(m-1)H(\xi)\right) \\
& = Cst
\end{aligned} \tag{18}$$

.2 IC development:

The simplifying assumptions gives the following IC constraint:

$$\begin{aligned}
(r_H - r_L) &= \Delta\pi(\bar{d} + \bar{d}^\star) && \text{(IC)} \\
&= \int_0^{\bar{d}+\bar{d}^\star} F_{L,L^\star}\,\mathrm{d}z - \int_0^{\bar{d}+\bar{d}^\star} F_{H,H^\star}\,\mathrm{d}z \\
&= e^{\frac{k}{\sigma}} \int_0^{\bar{d}+\bar{d}^\star} F_{H,H^\star}\,\mathrm{d}z - \int_0^{\bar{d}+\bar{d}^\star} F_{H,H^\star}\,\mathrm{d}z \\
&= (e^{\frac{k}{\sigma}} - 1) \int_0^{\bar{d}+\bar{d}^\star} F_{H,H^\star}\,\mathrm{d}z \\
&= (e^{\frac{k}{\sigma}} - 1)\sigma F_{H,H^\star}(\bar{d} + \bar{d}^\star) && (19)
\end{aligned}$$