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Bank Forex Exposure and Capital Requirements

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ABSTRACT

This paper focuses upon the measurement of foreign exchange exposure arising from a bank's foreign exchange dealing, and addresses the question of how capital adequacy requirements should be linked to measured exposure. In measuring exposure, two fundamental questions are answered. First, how should a portfolio of spot and forward forex positions be aggregated to derive a single measure of forex exposure? Second, how, if at all, should a book of positions in different currencies be aggregated into a single exposure measure? Drawing upon the answers to those questions, the paper then addresses the problem of how to determine the appropriate link between capital adequacy requirements and bank forex exposure, and provides an explanation and analysis of the proposals put forward by the Basle committee for the supervisory treatment of bank forex risk.

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In 1993 the Basle Committee[1] put forward proposals for determining the appropriate capital requirement for bank foreign exchange exposure. While banks have long had their own internal systems in place for measuring and controlling foreign exchange exposure, the Basle proposals have focused attention on the optimal design of such systems. The objective of this paper is to provide a simple exposition of the approach suggested by the Basle group, and its link to conventional approaches to measuring foreign exchange exposure. Because of the nature of banks' forex activities, three main issues are involved. First, how should spot and forward foreign exchange positions in a single currency be aggregated to derive an overall measure of exposure to that currency? Second, how should the exposure of a portfolio of positions in several currencies be measured? Third, what factors determine the appropriate capital requirement for a bank given its measured exposure to a range of currencies?[2]

The paper initially reviews the conventional definition of forex exposure, which relates to single cash flows in single foreign currency. This definition is then generalised to the situation in which a bank has a portfolio of spot and forward positions in a single currency in section 2. In section 3 the determination of an optimal capital requirement for forex exposure to a single currency is addressed, while in section 4, the analysis is further extended to the more realistic case in which the bank has positions in a number of currencies.

[1] Forex Exposure - The Conventional Definition

Conventional analyses of foreign exchange exposure revolve around a definition of exposure as the sensitivity of the domestic currency value of an asset to changes in the exchange rate. Thus if V is the domestic currency (AUD) value of an asset whose foreign currency (USD) value is X, and S is the exchange rate (written in direct quote form as the domestic currency price of foreign currency), we have:

$$V = X.S$$

Consequently, exposure EXP_F is defined as:

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[1] The Basle Committee on Banking Supervision is a Committee established in 1975 by the central bank Governors of the Group of Ten countries, which usually meets at the Bank for International Settlements in Basle. The proposals on foreign exchange exposure measurement and determination of appropriate capital requirements were originally released in April 1993. See Basle (1993)

[2] While the Basle committee focused on capital requirements for banks with a portfolio of foreign exchange positions, it is convenient to examine the single currency case first as an expository device.

$$EXP_F = \partial V / \partial S = X$$

so that the exposure measure is a foreign currency amount[3]. (Note that exposure is measured in this framework in terms of sensitivity of the domestic currency value to absolute changes in the exchange rate).

For many purposes, including that of aggregating exposure across multiple currency positions, it is convenient to measure exposure in domestic currency terms. This can be achieved by redefining exposure as the sensitivity of the domestic currency value to percentage (rather than absolute) changes in the exchange rate. Since

$$EXP_F = \partial V / \partial S = X$$

multiplying both sides by S yields

$$EXP_D = S.EXP_F = \partial V / (\partial S/S) = X.S$$

Exposure, measured as the sensitivity of domestic currency value to the percentage change in the exchange rate, is then measured as the domestic currency value of the foreign currency amount.

The Significance of Exposure

To assess the economic significance of exposure, it is necessary to combine the sensitivity measure derived above with a measure of volatility of the exchange rate, to obtain a measure of the volatility of domestic currency value of the position.

The volatility (standard deviation) of AUD value (V) can be derived from:

$$\partial V = X \, \partial S$$
$$\partial V = X \, S(\partial S/S)$$
$$\sigma(\partial V) = X.S.\ \sigma(\partial S/S)$$
$$\sigma(\partial V) = EXP_D.\ \sigma(\partial S/S)$$

The risk of the position $\sigma(\partial V)$ depends on exposure (EXP_D), and the volatility of the currency $\sigma(\partial S/S)$, calculated using percentage changes in the exchange rate.

This can be illustrated using a simple example. Suppose an asset has exposure X = USD 10m and the spot exchange rate S = 1.25, so that EXP_D = 12.5 mill. Using historical data for the AUD/USD exchange rate over the period 1982-92, $\sigma(\partial S/S) = .12$ p.a. approximately.

Then $\sigma(\partial V) = X.S.\ \sigma(\partial S/S)$

[3] See, for example Adler and Dumas(1985). For example, consider a USD 100 deposit which has AUD value = 125 at S = 1.25. If S = 1.26, its AUD value = 126. The change in the AUD value is given by D AUD value = 1 = 100 DS. Thus, the exposure = USD 100.

$= 10(1.25)(.12)$
$= \text{AUD } 1.5\text{m}$

Assuming that percentage changes in the exchange rate are normally distributed (i.e. the exchange rate is lognormally distributed) around a mean of zero, there is around a 32% chance that AUD value will increase or fall by more than 1.5m by the end of one year due to exchange rate changes[4].

[2] Aggregating Spot and Forward Forex Positions

The preceding analysis identifies the risk associated with a given foreign exchange position which is held for a defined time period as the product of exposure and currency volatility over that period. In assessing the risk facing banks from foreign exchange trading, two issues are relevant. First, what time period is the relevant one? Second, how should foreign currency amounts due or receivable at different points in time (as in forward contracts) be aggregated together? The first question is deferred to a subsequent section and the second question taken up in this section.

An Example[5]

An example will help to illustrate the issues involved and provide the framework for the subsequent analysis. Assume:

Spot rate (S) = 1.25 (direct quote)
Interest rates: Aust (r_a) = 0.04
U.S. (r_{us}) = 0.06

Assuming that covered interest parity holds, the forward rate at t (F_t) is then given by:

$$F_t = S\,(1 + r_a)^t/(1 + r_{us})^t$$

Consider a bank with the forex book shown in Table 1.

[4] This is calculated using the property of the normal distribution that the probability of an observation lying within one standard deviation of the mean is approximately 68%.
[5] This example is adapted from Putley (1990).

Table 1
Bank's Initial Forex Position

Term	AUD	USD	forward rate
Spot	-	-	
1 year	+10	-8.1539	1.2264
2 year	+10	-8.3105	1.2033
3 year	-10	+8.4703	1.1806
4 year	-10	+8.6333	1.1583
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Sum	0	+0.6392	

To measure this bank's exposure, consider the impact on its net worth of a depreciation of the AUD to S = 1.33 (r_a,r_{us} constant), ie $\Delta S = 0.08$. The bank's revaluation position at the new exchange rate[6] is shown in Table 2.

Table 2
Revaluation Position

Term	AUD original	AUD reval	Profit AUD	USD	forward rate
Spot	-	-			
1 year	+10	-10.64	-.64	-8.1539	1.3049
2 year	+10	-10.64	-.64	-8.3105	1.2803
3 year	-10	+10.64	+.64	+8.4703	1.2561
4 year	-10	+10.64	+.64	+8.6333	1.2324
	-----	-------	----	--------	
			0		

While the profit in AUD terms sums to zero, this does not allow for differential timing of those gains or losses. For example, the profit on the 4 year forward position represents the net cash flow available to the bank in 4 years if that position is closed out now at the new forward rate. It is thus necessary to calculate the net present value of those gains and losses. Discounting the future AUD profits and losses at the AUD interest rate, we obtain the change in the bank's net worth as:

$$\begin{aligned}\Delta V &= -.64/1.04 - .64/(1.04)^2 + .64/(1.04)^3 + .64/(1.04)^4 \\ &= -0.6154 - 0.5917 + 0.5690 + 0.5471 \\ &= -0.0910\end{aligned}$$

Since exposure has been previously defined as

[6] The forward rates shown have been recalculated using the new spot rate.

$\Delta V = (EXP_F) \times \Delta S$

and $\Delta S = 0.08$, we can calculate EXP_F as:

$EXP_F = -0.0910/0.08 = -1.1387.$

It is simple to demonstrate that this is equivalent to calculating

EXP_F = NPV(USD positions) : calculated using r_{us}

$= (-8.1539)/1.06 + (-8.3105)/1.06^2 + (8.4703)/1.06^3 + (8.6333)/1.06^4$

$= -1.1387$

Utilising the relationship between the forward and spot rates, it is also possible to express this exposure measure as:

EXP_F = NPV(AUD positions: calculated using r_A) converted into USD at S

Alternatively, it is possible to calculate the exposure as an AUD value measuring the sensitivity of NPV to percentage changes in the exchange rate.

Since $\Delta V = (EXP_D) \times \Delta S/S$

EXP_D = NPV (AUD positions)

A Formal Treatment

Consider a bank which at date 0 has a forward book comprising positions in the USD at dates i = 1....N of P_i (positive or negative) which have been established previously at forward rates F_i^* thus giving AUD obligations of $-P_i.F_i^*$. The AUD value of that book at date 0 when forward rates are F_i will be:

$$\text{AUDV}_0(\boldsymbol{F_i}) = \boldsymbol{V} == \sum_{\boldsymbol{i}=1}^{\boldsymbol{N}} [-\boldsymbol{P_i F_i^*} / (1+\boldsymbol{r_a})^{\boldsymbol{i}} + \boldsymbol{P_i F_i} / (1+\boldsymbol{r_a})^{\boldsymbol{i}}]$$

which using the covered interest parity relationship to substitute for F_i can be written as:

$$\text{AUDV}_0(\boldsymbol{F_i}) = \boldsymbol{V} == \sum_{\boldsymbol{i}=1}^{\boldsymbol{N}} [-\boldsymbol{P_i F_i^*} / (1+\boldsymbol{r_a})^{\boldsymbol{i}} + \boldsymbol{P_i S_i} / (1+\boldsymbol{r_f})^{\boldsymbol{i}}]$$

Note that the forward exchange rates currently prevailing do not enter into the expression for the value of the bank's position. (Historical values at which transactions were undertaken do appear). Because of covered interest parity, forward exchange rate movements are captured by movements in the spot exchange rate and domestic and foreign interest rates.

It is thus possible to decompose the exposure of the bank's forex position by examining the total differential:

$dV = (\partial V/\partial S)dS + (\partial V/\partial r_a)dr_a + (\partial V/\partial r_{us})dr_{us}$

which indicates that

Total Exposure = Spot forex exposure + AUD interest rate exposure +USD interest rate exposure

Differentiating and examining the components we have:

(i) $\frac{\partial V}{\partial S} = \sum \frac{P_i}{(1+r_f)^i}$ = Present Value (USD cash flows)

As outlined in the previous section, this measures the sensitivity of the position to absolute movements in the spot exchange rate. Multiplying this exposure measure by the spot rate (S) gives the Present Value of AUD cash flows which represents the sensitivity (exposure) to percentage changes in the spot rate:

$$dV = \frac{\partial V}{\partial S} dS = (\frac{\partial V}{\partial S}.S).(\frac{dS}{S})$$

(ii) $(\partial V/\partial r_a) = \partial(-\Sigma p_i F_i^* /(1+r_a)^i)/\partial r_a$

This measures the senstivity of the bank's forex forward positions to changes in AUD interest rates. Each component of this term represents the sensitivity of the present value of the AUD contractual cash flow at date i to a change in the AUD interest rate. Where P_i is positive, the AUD amount is a cash outflow, and can be interpreted as a balance sheet liability.

(iii) $(\partial V/\partial r_{us}) = \partial(\Sigma P_i S /(1+r_{us}))/\partial r_{us}$

This measures the sensitivity of the bank's forex forward positions to changes in USD interest rates.

This analysis demonstrates that total exposure from a foreign exchange book can be broken up into three components: spot exchange rate exposure, domestic interest rate exposure and foreign interest rate exposure. Because of the parity relationships, there is no independent forward foreign exchange rate exposure. While it would be possible to approach forex exposure by examining sensitivity to various forward rate scenarios, an alternative approach is available of decomposing exposures into the three components and managing them separately. Thus, for example, a forward forex deal can be aggregated with the spot position, and the implied USD and AUD money market positions aggregated with those money market books.

[3] Capital Requirements and Trading Limits for Bank Forex Activities

The preceding analysis provides a framework for analysing proposals for bank capital requirements based on forex positions as well as internal management decision making about position limits for the forex book.

Consider first the process of determining open position limits. When banks mark to market, the change in value of a forex position has an immediate impact on earnings for that period. For any forex position, calculated as in the preceding section, the probability of gains or losses from that position exceeding any specified amount within a specified time period can be easily calculated by noting that:

$$\text{Gain} = dV = EXP_D.z$$

where EXP_D is the measured exposure in AUD terms and z (=dS/S) represents the percentage change in the exchange rate over that period. Thus the probability of a gain less than -X (i.e. a loss greater than X) is given by:

$$\text{Prob (Gain} < -X) = \text{Prob } (EXP_D . z < -X)$$

or

$$\text{Prob } (z < -X/EXP_D) \text{ for } EXP_D > 0$$
$$\text{Prob } (z > -X/EXP_D) \text{ for } EXP_D < 0$$

Considering only the case where $EXP_D > 0$ for simplicity, this can be written as

$$\text{Probability (loss} > X) = \int_{-\infty}^{-X/EXP_D} f(z: \mu_t, \sigma_t) dz \qquad (1)$$

In equation (1), f is the (normal) probability distribution of percentage changes in the exchange rate over the time horizon t, where μ_t and σ_t are the expected value and standard deviation of z over that period.

Position limits are readily established from equation (1) by specifying a bound for maximum acceptable losses (X) and probability that this lower bound will not be breached within a specified time period (such as overnight). Using an estimate of exchange rate volatility σ_t , the specified loss amount X, and a maximum probability value (e.g. 2.5%), the maximum exposure position EXP_D consistent with this can be derived using probability tables.

In a similar vein, capital requirements based on forex exposure can be calculated. Given a capital allocation as a buffer for possible losses on forex trading of (for example) X, the probability that forex losses will wipe out that capital allocation increases directly with EXP_D. By fixing a specific probability value and making assumptions about the distribution function f, the ratio of X/EXP_D which achieves that probability can be determined. Hence, there will be a one for one link between the capital allocation required and the exposure measure.

The Basle Approach

The preceding analysis enables us to interpret the approach suggested by the Basle Committee for calculating exposure of a bank's foreign exchange book. The measure of exposure suggested there is:

> Exposure = Sum of spot plus forward positions (converted at the spot rate) into domestic currency value).

For banks trading foreign exchange options, this exposure measure is augmented by converting options positions into spot rate equivalents using the net delta of the forex options book. While the suggested approach ignores the discounting needed to properly aggregate spot and forward positions (which can be argued to be of second order of importance given the short term nature of most forward forex trading), for banks using NPV techniques, the Basle Committee suggests that they can take the NPV of forward positions.

The effect of this approach can be seen by referring back to our earlier example, reproduced as Table 3

Table 3
Bank's Position

Date	AUD	USD	forward rate
Spot	-	-	1.25
1 year	+10	-8.1539	1.2264
2 year	+10	-8.1305	1.2033
3 year	-10	+8.4703	1.1806
4 year	-10	+8.6333	1.1583
	-----	---------	
	0	+0.6392	

The Basle Exposure measure is given by

$$(Exp) = 0.6392(1.25) = AUD\ 0.799$$

Determining Capital Requirements: The Basle Approach

We have seen that changes in bank value are linked to exposure as measured by the Basle Committee in the following way.

$$dV = (\partial V/\partial S)dS = X.dS = (X.S).(dS/S) = (EXP_D).(dS/S)$$

Moreover, we have seen that the determination of a capital requirement requires some assumptions to be made about the probability distribution of dS/S. Two suggested approaches were presented in the Basle report. The first (the "shorthand" approach) apparently short circuits the need for information on the probability distribution, since capital required (K) is set such that

$$K = 0.08 (EXP_D)$$

This can be interpreted as an attempt to ensure that adequate capital is held to cover losses arising from the probability of a change in the exchange rate in an adverse direction of $dS/S > 0.08$, since

$$dV > K$$
$$= (Exp).(dS/S) > 0.08(Exp)$$
$$= dS/S > 0.08$$

While this approach short circuits the need for any explicit assumption about the probability distribution of dS/S, it involves an implicit assumption about the probability distribution of dS/S. That in turn requires an assessment of what period is appropriate for measurement of exposure. The Basle group suggest a period of two weeks - which seems very conservative, given that banks monitor and change their positions continuously.

Using Australian historical data for the period 1982 - 1992, $\sigma(ds/s) = .1231$ p.a.., so that

$$\sigma(ds/s) = .1231/\sqrt{26} = .1231/5.1 \text{ per fortnight}$$
$$= .024 \text{ per fortnight}$$

The probability of dS/S >0.08 in an adverse direction over a two week horizon is thus equivalent to the probability of a N(0,1) variable exceeding 0.08/0.024 = 3.33, which is around 0.04%, i.e. 4 times in 10,000!

Determining the Capital Requirement (Simulation Method)

The Basle Committee also suggests an alternative approach to determining capital requirements based on simulation of possible losses arising from the current position using historical exchange rate data. The approach involves the following steps.

(1) Obtain historical daily exchange rates from an "observation" period, which is suggested as 5 years.
(2) Determine a "holding" period for current forex position, suggested as two weeks (10 trading days)
(3) Calculate simulated losses based on the asssumed holding period over the observation period, which would have occurred had the current forex position been held then. Table 4 provides an example in which the bank has a current exposure of -10 USD. Assuming this position had been created at date -13 and held for ten days until date -3, the bank would have made a profit of AUD 0.15. As shown, holding the same position for 10 days starting at day -12 and day -11 would have generated zero profit and a loss of AUD 0.09 respectively.

Table 4
Simulation Approach

DATE (-t)	RATE	POSN (USD)	VALUE at -t	VALUE at at -(t-10)	PROFIT
0 (today)					
-1	1.2440				
-2	1.2400				
-3	1.2350				
.	.				
.	.				
.	.				
-11	1.2350	-10	12.35	12.44	-.09
-12	1.2400	-10	12.4	12.4	-
-13	1.2500	-10	12.5	12.35	.15
.					
.					

Utilising five years of data (with approximately 250 trading days in each) this approach will generate around 1250 hypothetical profit or loss values. To the extent that past history provides a good guide to future volatility of the exchange rate, this distribution of profit and loss values can be taken to represent the probability distribution of possible profits and losses likely from the current exposure.

(4) The worst outcome or some quantile position from the distribution is taken to give a confidence measure of the worst possible outcome. The Basle Committee suggests use of the 95% quantile - i.e only 5 in 100 losses greater than this.

(5) The capital requirement is then set as equal to that worst case outcome, plus an additional amount equal to 3% of the exposure calculated under the short hand method.

In the case of a single currency, it should be possible to calibrate the shorthand and simulation approaches to give exactly equivalent results. However, in the case of multiple currencies the alternatives may differ.

[4] Forex Exposure in a Portfolio Context

The preceding discussion has focused upon measuring exposure in the context of a bank trading a single foreign currency, in order to simplify the analysis. In practice, of course, banks have a book of multiple currency positions, raising the question of how to assess the aggregate exposure of that book.

Denoting the percentage change in currency i whose exchange rate is given by S_i as $dS_i / S_i = z_i$, and exposure to that currency by C_i, the change in value of the bank's position due to exchange rate changes can be written as:

$$dV = C_1 z_1 + C_2 z_2 + ...+ C_n z_n = C^{/} z$$

where $C^{/} = [C_1, C_2, ...C_n]$ and $z^{/} = [z_1, z_2, ...z_n]$.

Denoting the expectations operator by E[ ],

$$\sigma^2_V = E[dV^2] = E[dVdV^{/}] = E[\, C^{/} z z^{/} C] = C^{/} \, E[zz^{/}]C = C^{/} \Sigma C$$

As in the case of a single foreign currency, having obtained the probability distribution function of V a capital requirement (K) can be determined such that the probability of losses greater than K can be calculated. However, to determine the probability, it is apparent that a knowledge of Σ, the covariance matrix between currencies is required.

Levonian (1994) has examined this issue and demonstrates that the Basle proposals can be interpreted in the following way. First, if it is assumed that there is no correlation between the bilateral exchange rates ($\rho_{ij} = 0$ for all i not equal to j) then the covariance matrix Σ becomes diagonal, and $\sigma^2_V = C^{/} \Sigma C = C_1^2 \sigma_1^2 + ...C_n^2 \sigma_n^2$. If it is further assumed that all exchange rates have the same volatility (σ) and exposures in all currencies are of the same absolute size (C), $\sigma^2_V = nC^2\sigma^2$. In this case, a capital requirement can be based on C which is the sum of exposures of all positions (long and short) ignoring the sign of those positions. In Levonian's terminology, this is equivalent to setting a capital requirement based on the measure GAP = L + S, where L is the sum of long currency positions and S is the sum of short currency positions.

If instead, it is assumed that all bilateral exchange rates are perfectly positively correlated σ^2_V = $(C_1\sigma_1 + ...+ C_1\sigma_n)^2$. Again if it assumed that all exchange rates have the same volatility (σ), then $\sigma^2_V = \sigma^2 (C_1 + ...C_n)$., so that a capital requirement can be set by reference to exposure based on the sum of long and short positions - this time taking account of signs. In Levonian's terminology, the appropriate measure is NAP = |L-S|.

In practice, of course, neither of these two special cases apply, and the Basle approach takes an intermediate position, involving the following steps. First, for each currency, sum spot plus forward positions (converted at the spot rate) plus the net delta of the forex options book etc. (For banks using NPV techniques, take NPV of forward positions). This generates an exposure measure for each currency. Then determine overall exposure (as a basis for determining capital requirements) as:

Exposure = Max [sum short currency positions, sum long currency positions]
$= \text{Max}\ [\Sigma S_i, \Sigma L_i] = \text{Max}\ [S,L]$
where S_i (L_i) is the AUD value of the short (long) position in currency i.

This is illustrated by example in Table 5

Table 5
Bank Multi Currency Position

	Bank's Position		
Date	DM	NZD	USD
Spot rate	*(1.4)*	*(0.8)*	*(1.25)*
1 year	+1	10	-8.1539
2 year	+12	-4	-8.1305
3 year	-13	3	+8.4703
4 year	-1	-13	+8.6333
	-----	----	---------
	-1	-4	+0.6392

Based on the figures given in Table 5, the Basle Exposure measure (Exp) is given by

Exp = Max[(1)(1.4) +(4)(0.8) , 0.6392(1.25)]

= Max [AUD 3.6, AUD 0.799]

= AUD 3.6

As Levonian demonstrates, this exposure measure which he denotes [BAP] can be shown to be linked to GAP and NAP by:

$$BAP = 0.5 [GAP + NAP]$$

In this sense, the Basle measure is a compromise which assumes some, but not perfect correlation, between bilateral exchange rates. Historical information on the correlation between bilateral exchange rates involving the AUD is given in Table 6 where the existence of significant correlation is apparent.

Table 6
Correlation coefficients: AUD bilateral exchange rates
1982-1993 (monthly data)

	yen	usd	uk	dm
usd	0.81			
uk	0.87	0.66		
dm	0.96	0.74	0.94	
nzd	0.50	0.35	0.70	0.59

The Basle capital requirement is then determined as

Capital Requirement (Shorthand Method) = 0.08 x BAP

The alternative approach of simulation follows the same method as outlined earlier in the single currency case. However, differences could arise here because the simulation approach allows explicitly for the observed correlation between bilateral exchange rates over the past two years, whereas the shorthand method involves some arbitrary assumption about that correlation.

[5] Conclusion

The proposal for imposition of capital requirements for bank forex exposure has made the question of measuring the size of that exposure, and assessing its potential for reduction in bank net wealth an important and relevant topic. While the principles underlying the determination of the exposure of a forex book are straightforward, constructing an exposure measure is made complex by the difficulty of allowing for correlation between bilateral exchange rates. A further factor complicating the determination of an appropriate capital standard lies in the choice of an appropriate assumed holding period for bank forex positions. Both of these topics warrant further research.

REFERENCES

Adler M and B Dumas (1985) `Exposure to Currency Risk: Definition and Measurement' Financial Management, 13, 2, 41-50.

Basle (1993) The Supervisory Treatment of Market Risks, pp 33-42, Basle Commtitee on Banking Supervision, Bank for International Settlements, Basle, April

Levonian M E (1994) “Bank Capital Standards for Foreign Exchange and Other Market Risks” Federal Reserve Bank of San Fransisco Economic Review, Number 1, 3-18.

Putley (1990) "Foreign Exchange and the Uses of Discounting" The Journal of International Securities Markets, 4, Autumn, 263-8.

Zimmer S and R McCauley (1991) `Bank Cost of Capital and International Competition' Federal Reserve Bank of New York Quarterly Review, 15, 3-4, Winter, 33-59.