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Shocks: What is the Role of Value at Risk Models?**



## The International Transmission of Financial Shocks: What is the Role of Value at Risk Models?

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### Abstract

This paper investigates the role of modern risk management tools, in particular of Value at Risk (VaR) models, in the international transmission of financial shocks. Using BIS data on the portfolio positions of international banks we estimate the portfolio readjustments dictated by VaR models following different types of loss events. We distinguish between three types of loss events, an extreme observation event, a mean shift event and a volatility event and in each case calculate the effect on banks' VaR during the Asian crisis. We then compute a VaR-elasticity and estimate which countries were prone to suffer most from pressure on their currency through this channel. We find that observed contagion can be explained surprisingly well with these VaR-elasticities and that VaR induced outflows may have been sizeable. This suggests that, with homogenous investors (who hold similar positions and follow the same re-balancing strategies), VaR models may indeed have contributed to increasing global systemic risk.

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## I. Introduction

*So called value-at-risk models (VaR) blend science and art. They estimate how much a portfolio could lose in a single bad day. If that amount gets too large, the VaR model signals that the bank should sell. The trouble is that lots of banks have similar investments and similar VaR models. In periods when markets everywhere decline, the models can tell everybody to do the same things at the same time, making market conditions much worse. In effect, they can, and often do, create a vicious feedback loop.*

The Economist, October 14-20, 2000, p.106

Market participants have suggested that modern risk management techniques, in particular Value at Risk models, have contributed to the transmission of currency and financial crises around the globe.<sup>1</sup> The idea, as expressed in the above quotation from the Economist, is that an increasing number of financial institutions use the same portfolio management models which in times of market turbulence leads to the selling of many assets when an adverse shock affects only one asset. For instance, following a currency crisis in Thailand the Value at Risk of an emerging market portfolio may increase and investors may rebalance their portfolios by selling correlated assets of other countries, thereby possibly triggering further currency crises. Note that this form of financial contagion is completely mechanistic, that is the VaR model creates a direct link between positions in the first asset and correlated assets in a similar way as trade competition between countries creates a link between their asset valuations.<sup>2</sup> In other words, this form of financial contagion may occur even if there is no generalized revision of expectations on the returns of all relevant assets.

As pointed out by Smith and Shinasi (1999) this kind of contagious behavior is not unique to VaR models. Other portfolio management rules, such as return benchmarking rules or rules that trade-off volatility and return may lead to similar portfolio readjustments in the face of a shock to one asset. However, VaR models have certainly been the most prominently discussed “culprits” since they had become increasingly fashionable during the nineties. At the same time, regulatory agencies have increasingly required financial institutions to implement Value at Risk

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<sup>1</sup> See e.g. Folkerts Landau and Garber (1998), The Economist (1999)

<sup>2</sup> In the terminology introduced by Masson (1998), this is a financial spillover.

and the Basle Committee had proposed to increase their use in banking supervision.<sup>3</sup> All of this raises the question for banking supervisors, financial institutions and emerging markets. How important are VaR models in transmitting selling pressure? Would a generalized use of VaR models increase systemic risk?

This paper addresses these questions by providing estimates of the extent of portfolio rebalancing of international banks during the Asian crisis. As bank flows to emerging markets have been among the largest as well as the most volatile ones during times of crisis we will focus on them.<sup>4</sup> Due to data availability we will use stock market rather than loans market to compute the variance/covariance. This might not pose a problem as these markets are correlated during financial turmoil. In a first step we show that the re-balancing is less mechanistic than commonly thought since the portfolio manager needs to decide what kind of event the shock to the first asset represents. We distinguish between three kinds of events: an extreme observation event, a mean shift event and a change in variance event. We show that the possible readjustments of the portfolio depends on the kind of event and that contagious selling does not always follow. The second step is to estimate the extent to which the reduction of bank lending during the Asian crisis may have been attributed to VaR models. For this purpose we assume that all major banking institutions choose the same portfolio readjustment strategy and we apply this to the situation during the Asian crisis. This allows us to quantify the outflow of bank lending that could be attributed, at least in theory, to VaR models.

Our findings are as follows:

- VaR models do not necessarily create more homogeneous behavior of investors following a negative shock to one country,
- the more there is diversity in the interpretation of a shock the less homogeneous and therefore contagious the reactions will be
- however, if all banks follow the dictates of the VaR-model and readjust in the same manner, the empirical estimates for the Asian crisis suggest that a substantial outflow from emerging markets can be explained,

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<sup>3</sup> See Bank for International Settlements (1996)

<sup>4</sup> See Van Rijckeghem and Weder (2000) for a more detailed discussion of the role of international banks.

- observed contagion can be explained surprisingly well by a model based on VaR.

The paper is organized as follows: section II gives a brief description of the VaR model illustrating it with a three asset portfolio. Section III distinguishes three kinds of shocks and shows their effects on VaR in general and for the specific three asset portfolio. Section IV shows how the rebalancing options are in theory. Section V provides estimates for the adjustment during the Asian crisis and compares them to the available data and Section VI concludes.

## II. The Value at Risk model

Value at Risk is a tool developed in the early nineties in order to control portfolio risk.<sup>5</sup> Since then, it has become popular among large banks leading to a variety of publications concerning this topic.<sup>6</sup> The Value at Risk refers to the maximum expected loss of a portfolio given a distribution of losses and gains, a predefined time period and a given probability. For example, a portfolio currently valued at US dollars 10'000.- might have a VaR of US dollars 600.- given a one day time-horizon and a 95% confidence interval. This means, that the portfolio is unlikely (would only happen five times out of hundred) to lose more than US dollars 600.- during the following twenty four hours.

In order to calculate the Value at Risk of a given portfolio some inputs are needed. First, the distribution of the capital gains/losses must be identified. This can be done either by plotting the historical data and fitting a distribution or by assuming a certain distribution. Most frequently the normal distribution is used (especially before the Asian crisis). We follow this approach in this paper since our aim is not to provide a correct model of the actual risks but to estimate the actual impact real VaR models might have had during the Asian crisis.<sup>7</sup> Second, the relevant time

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<sup>5</sup> A similar method has first been presented by Telser, Lester G. (1955)

<sup>6</sup> Jorion, Philippe (1997); Jorion, Philippe (1996); Bank for International Settlement (2000); Beder, Tanya Styblo (1995)

<sup>7</sup> After the Asian crisis one of the main criticisms of VaR models was that the normal distribution underestimates the probability of extreme observations suggesting a lower risk since the distribution of financial asset returns tend to have 'fat tails'. Furthermore, lower capital gains are suggested as financial asset distribution are in general right skewed.

horizon needs to be defined (usually one day). Of course, longer time horizons are associated with a flatter distribution of returns since observations far away from the mean value become more likely. Third, the first two moments of the distribution, the mean value and the variance need to be determined. This can be done through a variety of ways. For a simple illustrative three-asset exercise we will use values supplied by the extensive and widely used RiskMetrics Database of the J.P. Morgan company.<sup>8</sup> Finally, the maximum amount of risk the portfolio shall inhibit has to be decided. Mostly the 95% confidence interval is used, however, the Basle Committee suggests a 99% confidence interval.<sup>9</sup> Bankers Trust for instance uses this recommended confidence level, while other banks such as Citibank (95.4%) and J.P.Morgan (95%) use lower levels. In this paper the 95% confidence level shall be used throughout the analysis.

The Value at Risk is then calculated as:

$$R^* = \bar{m}_P - a \cdot s_P \quad (1)$$

Where  $\bar{m}_P$  represents mean return of portfolio P,  $a$  corresponds to the value of the one-tailed confidence level of the normal distribution (i.e. for a 95% confidence level it corresponds to a value of +1.645) and  $s_P$  is the portfolio variance. Then the  $R^*$  represents the worst loss the portfolio will incur with a probability of 95% during the specified time horizon. This specific return will be called the cut-off return.  $R^*$  is normally a negative number denoting the maximum possible loss. Multiplying it with the initial portfolio value (PV) will give the maximum loss in terms of money. This value corresponds to the value at risk amount.

$$VaR = PV \cdot R^* \quad (2)$$

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<sup>8</sup> RiskMetrics is a methodology to estimate market risk based on the Value-at-Risk approach. The tool is called VaR Calculator. This calculator can be accessed at the RiskMetrics homepage and can be used for VaR computations for self-defined portfolios. The database offered alongside this computation engine includes a set of consistently calculated volatilities (approx. 450) and correlation forecasts (approx. 100'000). The RiskMetrics database covers foreign exchange, money markets, interest rate swap, bonds, equity indices in 23 countries, and different commodities (approx. 3300 different assets). The available data on the net starts to be recorded from 1996 onwards. RiskMetrics was introduced on October 1994. See RiskMetrics 'Technical Document' of J.P. Morgan. Homepage: <http://www.riskmetrics.com/>. There are other methods that are based on VaR calculations. For example Bankers Trust RAROC. This method allows the use of other distributions than the normal one and assets with non-linear payoffs in order to allow for derivatives.

Since the time horizon of VaR is very short the mean return  $\mathbf{m}_P$  is usually set to zero. We will follow this convention. Thus  $R^*$  becomes:

$$R^* = -\alpha s_P \tag{3}$$

For a case of a fully invested portfolio consisting of three assets,  $s$ ,  $j$  and  $k$  the portfolio variance can be calculated as:

$$s_P = \sqrt{[s \ j \ k] \ ? \ \begin{bmatrix} s \\ j \\ k \end{bmatrix}} \quad \text{where : ?} = \begin{pmatrix} s_s^2 & s_{sj} & s_{sk} \\ s_{sj} & s_j^2 & s_{jk} \\ s_{sk} & s_{jk} & s_k^2 \end{pmatrix} \tag{4}$$

which reduces to

$$s_P = \sqrt{s_s^2 s_s^2 + j^2 s_j^2 + k^2 s_k^2 + 2s_j s_{sj} + 2s_k s_{sk} + 2j k s_{jk}} \tag{5}$$

As an example, assume a portfolio denominated in Swiss Francs whose starting value  $V_0$  is 100.-. Asset S is the Swiss blue chips equity market index. This asset represents the safest investment of the three assets, first due to the lower volatility and second as its currency risk is zero. The correlation of asset SMI and the two other assets is almost zero. Asset J represents the Japan Nikkei 225 equity index. The third asset k represents the Thai SET equity index. Asset J and K have a high correlation and are more volatile than the Swiss market index. Again we assume that the portfolio must be fully invested.

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<sup>9</sup> Bank for International Settlements (1996), p.2

Table 1: Example of VaR for a three asset portfolio<sup>10</sup>

	Variable	Value
Portfolio Value	$V_0$	100
Confidence level 95 %	a	1.65
Asset s		
Standard deviation of asset s	$s_s$	1.123%
Correlation of asset s and j	$\rho_{sj}$	0.034% <sup>11</sup>
Correlation of asset s and k	$\rho_{sk}$	0.033%
Share of j at time zero	$s_0$	50%
Asset j		
Standard deviation of asset j	$s_j$	1.346%
Correlation of asset j and s	$\rho_{sj}$	0.034%
Correlation of asset j and k	$\rho_{jk}$	0.0309%
Share of j at time zero	$j_0$	25%
Asset k		
Standard deviation of asset k	$s_k$	2.199% %
Correlation of asset k and s	$\rho_{ks}$	0.033%
Correlation of asset k and j	$\rho_{jk}$	0.0309%
Share of k at time zero	$k_0$	25%

Note: s=Swiss SMI, k= Thai SET, j=Japanese NIKKEI

For this example, using equations (2) and (4) the portfolio standard deviation can be calculated. It is  $s_p=0.937$  which leads to a Value at Risk of  $=-1.546\%$ , meaning that the portfolio will not lose more than CHF 1.546 over the next day (with prob. 95%).

<sup>10</sup> Data is from Nov. 1999 Risk-Metrics databank.

<sup>11</sup> Note: to compute the VaR we need to substitute covariance by correlations. This can be done by the standard formula:  $\sigma_{AB}=\rho_{AB}\sigma_A\sigma_B$

### III. Effects of different types of events on impact

Next, we consider the situation of a portfolio manager after there has been a loss on one of the assets, that is we discuss how different types of loss events affect the VaR. We examine three kinds of events: an extreme observation event, a mean shift event<sup>12</sup> and a change in variance event<sup>13</sup> and we calculate the impact on VaR for each of these events.<sup>14</sup>

#### *Extreme observation event*

The VaR tells that in 95 of 100 cases the one day loss will be less than R. Put the other way around, in 5 out of 100 these cases the loss will be higher. This would correspond to an extreme observation in a constant distribution, a case illustrated in appendix figure 1. What happens to the VaR after such an extreme observation event? Using the example introduced in the previous section, we assume a 20 percent loss of the Thai shares in the portfolio. Since the portfolio manager believes that this is one of the rare extreme observations the variance and mean of the distribution remain constant. A 20 percent loss on the Thai equity share means that of its CHF 25.- value only CHF 20.- are left after the event. The entire portfolio value decreases to CHF 95.- Therefore, we have an important repercussion on the shares of each equity. The shares of s and j increase while the share of t decreases.

The overall change in VaR is equal to:

$$\Delta R^* = \frac{\Delta R^*}{s} s + \frac{\Delta R^*}{j} j + \frac{\Delta R^*}{k} k \quad (6)$$

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<sup>12</sup> Shinasi and Smith (1999), Kodres and Pritsker (1999), Calvo and Mendoza (2000) consider such events.

<sup>13</sup> Shinasi and Smith (1999), Calvo (1998) and Calvo (1998) consider this type of event.

<sup>14</sup> A further source of change in VaR might be of interest, namely an insurance-loss event. The moral hazard discussion suggest that investors presumed that IMF intervention worked like an insurance from high losses. The distribution of asset returns would therefore not be symmetric but cut on the left. The loss event of August 1998,

while the following equation has to hold as well:  $\Delta s = -\Delta j - \Delta k$  as the shares need to sum up to 1 again.

Therefore, the relevant equation is:

$$\Delta R^* = \left( \frac{\partial R^*}{\partial j} - \frac{\partial R^*}{\partial s} \right) \Delta j + \left( \frac{\partial R^*}{\partial k} - \frac{\partial R^*}{\partial s} \right) \Delta k \quad (7)$$

Performing the necessary derivations leads to the following result:

$$\Delta R^* = -(\alpha/\sigma_p)[s\sigma_s^2 - j\sigma_j^2 + (j-s)\sigma_{sj} + k\sigma_{sk} - k\sigma_{jk}]\Delta j - (\alpha/\sigma_p)[s\sigma_s^2 - k\sigma_k^2 + j\sigma_{sj} + (k-s)\sigma_{sk} - j\sigma_{jk}]\Delta k \quad (8)$$

$$\text{where } \sigma_p = \sqrt{s^2\sigma_s^2 + j^2\sigma_j^2 + k^2\sigma_k^2 + 2sj\sigma_{sj} + 2sk\sigma_{sk} + 2jk\sigma_{jk}} \quad (9)$$

Note that, if the relation between  $R^*$  and the respective shares is not linear this result will be inaccurate. Intuitively, one might assume that an unnecessary extra risk is incurred on an undiversified portfolio. Therefore, extremely low or extremely high shares of any asset  $i$  will lead to higher risk and an  $R^*$  lower than the one that could be achieved through comprehensive diversification. A very low share of one asset other things being equal might go hand in hand with a quite low  $R^*$ . On the other hand, a very high share of one asset again reduces the gains of diversification therefore leading to a very low  $R^*$  again. Therefore, it is sensible to assume that the  $R^*$  and asset  $i$  relationship is concave.<sup>15</sup> Keeping this in mind, we will follow the analysis using the linear approximation.

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when the IMF did not bail out Russia may have had the effect on investors of eliminating this implicit insurance. However, the effect on VaR is difficult to calculate since the extent of expected ex ante insurance is unknown.

<sup>15</sup> The second term of the Taylor expansion of each derivation tells us if the reaction of  $R^*$  is underestimated (positive sec. term) or overestimated (negative sec. term). For the derivation of  $R^*$  over any share 'i', the second term is positive (negative) if the second derivative is positive (negative). The second derivative is positive if  $\{[a^2 i^2 \sigma_i^2 / \phi^3 - 1/\phi] > 0\}$  or  $[i^2 \sigma_i^2 > \phi^3]$ . This, nevertheless must not be true. For small changes in shares the potential error is small. Nevertheless, it should be noted that the relevant equation contains three derivations of which each may have its own error included.

In this specific example the result is:

$$\Delta R^* = (\alpha/\sigma_p) \cdot [s\sigma_s^2 - j\sigma_j^2 + (j-s)\sigma_{sj} + k\sigma_{sk} - k\sigma_{jk}] \cdot [s\sigma_s^2 - k\sigma_k^2 + j\sigma_{sj} + (k-s)\sigma_{sk} - j\sigma_{jk}]$$

$$\Delta R^* = 1.756 \cdot -0.043 \cdot -0.815$$

$$\Rightarrow \Delta R^* = -0.076\Delta j + (-1.431)\Delta k$$

The changes in shares are the following:

Asset k	↓	from 25/100 to 20/95	$\Delta k = -0.039$ percent
Asset j	↑	25/100 to 25/95	$\Delta j = 0.013$ percent
Asset s	↑	50/100 to 50/95	$\Delta s = 0.026$ percent

Notice that the changes fulfil the condition  $\Delta s = -\Delta j - \Delta k$ .

Therefore, the  $R^*$  change is  $\Delta R^* = +0.055$  percent and the new cut-off return is equal to  $R^* = -1.491$  percent. This change in  $R^*$  represents an improvement in the risk situation for the portfolio. This is not surprising as the share of the riskiest asset has decreased. Intuitively, it can be stated that a decrease of any portfolio whose volatility is greater than the portfolio's volatility will trigger a decrease in  $R^*$  and therefore improve the portfolio's risk level. Nevertheless, the correlation among assets needs also to be looked at in order to make a final statement.

*The mean shift event (Change in the first moment of the distribution)*

Again, we assume that a considerable loss has been recorded on one asset. Such a loss was not expected by the portfolio manager as the distribution is supposed to have shifted downwards all of a sudden. As a first consequence, this portfolio loss results in a change in shares equal to the one observed in the preceding section. Nevertheless, the portfolio manager needs to implement the new information, i.e. the downward shift of the mean, into the considerations of how to manage the portfolio. As can be seen in figure 2 of the appendix, each

point of the distribution is shifted by the shift of the mean. So, also the  $R^*$  shifts downwards to the same extent as the mean does.

One might argue that it is very unrealistic to observe a shift of the mean in this extent. If the mean is computed through historical data, as new data come in only a slow downward shift of the mean is possible. But this case might be more relevant than it seems at first sight. Let us regard a portfolio which includes assets with currencies different to the one the portfolio has. Then, a continuous depreciation of one foreign asset can be thought of as a shift in the mean return in that asset in terms of the base currency. Of course, the volatility will be unaffected by such an event. But still, the mean return should be adjusted downwards by the portfolio manager by the proportion of the devaluation.

Next, the change shall be deduced analytically. Recall that the correct formula of the cutoff return is  $R^* = \mu_p - \alpha \sigma_p$  where  $\mu_p$  is equal to the portfolio expected return. This is typically set equal to zero due to the short time horizon regarded. The change in the mean of one asset naturally will decrease the change in the portfolio mean. So,  $\mu_p$  changes to  $\mu_p + \psi$  where  $\psi$  is equal to the change on the portfolios mean due to the change in asset  $i$  mean. The cutoff return changes to  $R^* = \mu_p + \psi - \alpha \sigma_p$ . As  $\mu_p$  has been set zero, the formula reduces to  $R^* = \psi - \alpha \sigma_p$  and so the change cutoff return change is  $\Delta R^* = \psi$ .

The portfolio return is defined as:  $r_p = ar_a + br_b + cr_c + \dots + nr_n$  for  $n$ -assets. So, the derivation of  $r_p$  over  $r_i$  is simply its share  $i$ .

Therefore,  $\Psi = \frac{\partial r_p}{\partial r_i} = i \Delta r_i$  (10)

To illustrate this event we will use the same example as above. Additionally to the given data, we will assume a change in the mean of asset  $t$  by 20 percent. Therefore,  $\psi = 0.25 \cdot (-0.2)$ .  $R^*$  decreases by 5 percent which represents a substantial decrease compared to the decrease of 0.055 percent resulting in the previous section.

Using the above data, the cut-off return changes from  $R^* = -1.546$  percent to  $R^* = -6.546$  percent. The portfolio manager will surely need to perform massive shifts in the portfolio shares to offset such a dramatic change. In addition to this, the effect of the changes in shares analogous to the previous section analysis will affect  $R^*$  as well.

*The Variance Event (Change in the Second Moment of the Distribution)*

As a further source of portfolio loss we will look at an increase in the volatility of an asset (appendix figure 3).

Again, we will assume that the Thai asset is the one whose volatility increases. Its volatility shall be assumed to increase from 2.199 percent to 2.5 percent, i.e. by 0.301 percent.

The relevant equation is the following:

$$\frac{\partial R^*}{\partial s_k} = \frac{a}{s_p} k^2 s_k \quad (11)$$

$$\text{where } s_p = \sqrt{s_s^2 s_s^2 + j^2 s_j^2 + k^2 s_k^2 + 2s_j s_{sj} + 2s_k s_{sk} + 2jk s_{jk}}$$

Using the above figures leads to:

$$\frac{\partial R^*}{\partial s_k} = \frac{a}{s_p} k^2 s_k = 11.75 \cdot 0.0625 \cdot 2.199 \cdot 0.301 = 0.073\%$$

Therefore, the cut-off return decreases from  $R^* = -1.546$  percent to  $R^* = -1.619$  percent.

#### IV. Portfolio Re-balancing Options following different Types of Events

We have seen that the different kinds of loss events affect the  $R^*$  differently. According to our example a capital event might increase  $R^*$ , a mean shift event decreases it dramatically and a volatility event decreases it moderately. It should be noticed that these events might as well take place jointly. In that case the predominant one would clearly be the mean shift event. The next question we will turn to is the possibilities that a portfolio manager has to offset any adverse cut-off return movements. If the VaR decreases below the border VaR, then the manager needs to perform certain operations in order to reverse this change.

The variables the manager is able to manipulate are the shares of the different assets. In order to decrease the VaR the portfolio manager will typically sell part of the risky assets and buy safer ones. The asset responsible for the shock might need special attention. Selling it right after a shock in order to readjust VaR might be imprudent. We will therefore leave this asset out of our re-adjustment considerations. So, in our earlier example, the portfolio manager would have two variables which can be manipulated. We are thus facing a set of solutions rather than one single solution.

Two constraints are given: the shares need to sum up to one and the change in  $R^*$  needs to be positive and at least as big than what is needed to reach the border VaR again. This necessary change in  $R^*$  shall be denoted by  $\Delta R^*_{\min}$ .

The relevant equation is then:

$$-\Delta R^*_{\min} \geq (\alpha/\sigma_p)[s\sigma_s^2 - j\sigma_j^2 + (j-s)\sigma_{sj} + k\sigma_{sk} - k\sigma_{jk}]\Delta j + (\alpha/\sigma_p)[s\sigma_s^2 - k\sigma_k^2 + j\sigma_{sj} + (k-s)\sigma_{sk} - j\sigma_{jk}]\Delta k \quad (12)$$

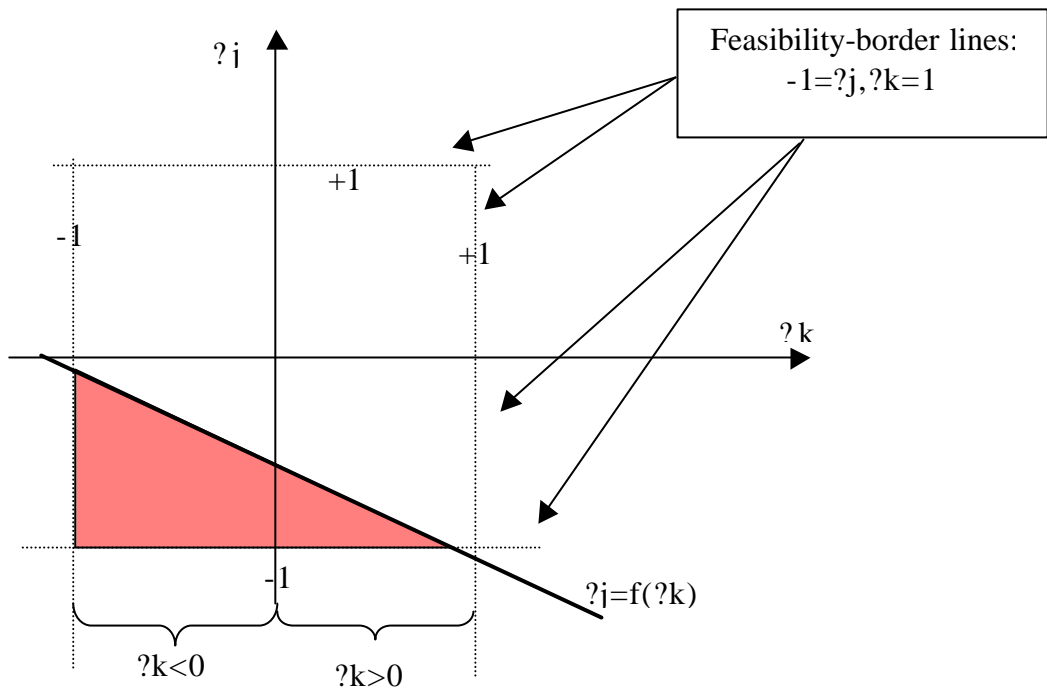
This can be rewritten as:

$$\Delta j \geq \{1/[s\sigma_s^2 - j\sigma_j^2 + (j-s)\sigma_{sj} + t\sigma_{st} - t\sigma_{jt}]\} \{(\Delta R^*_{\min})/(\alpha/\sigma_p) - [s\sigma_s^2 - t\sigma_t^2 + j\sigma_{sj} + (t-s)\sigma_{st} - j\sigma_{jt}]\Delta t\}$$

$$\Delta j = \frac{s_p \Delta R_{\min}^*}{a [j s_j^2 - s s_s^2 + (s-j) s_{sj} + k s_{jk} - k s_{sk}]} - \frac{k s_k^2 - s s_s^2 + (s-k) s_{sk} + j s_{jk} - j s_{sj}}{j s_j^2 - s s_s^2 + (s-j) s_{sj} + k s_{jk} - k s_{sk}} \Delta k \quad (13)$$

The solution set can be depicted on the two dimensional space. The region of possible solutions is constrained first by the condition that the shares must add up to one and second by the above condition. The above condition can be depicted as a line in the  $\Delta j$ - $\Delta k$  space.

Figure 1: Solution set for VaR adjustment (general graph)



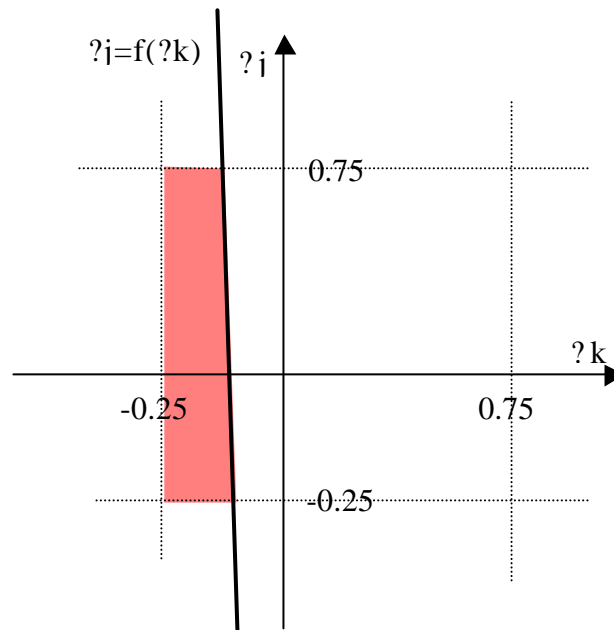
In the example used until now, the border line would have the form:

Figure 2: Solution set for VaR adjustment (specific graph)

$$\Delta j = -13.1 \cdot \Delta R^*_{\min} - 18.7 \cdot \Delta k$$

for  $\Delta R^*_{\min} = 0.3$

$$\Rightarrow \Delta j = -12.7 - 18.7 \cdot \Delta k$$



The curve's slope and intersection-point with the  $\Delta j$ -axe is crucial to the question of the necessary adjustments.

The following statements can be made by looking at equation (13): the more volatile the asset  $j$  is in comparison to asset  $s$ , the higher this point will be. In our example the difference is very small leading to a relatively low intersection point. For strong corrections of  $R^*$  (high  $\Delta R^*_{\min}$ ) the intersection point will be rather low.

The slope in brief, measures the relative impact of a change of share  $k$  on  $R^*$ . Relative to the corresponding effect of share  $j$  and both 'corrected' by the implied consequences of a change in  $s$ .

One interesting point is the correlation between the two assets. A vertical curve would mean that it is irrelevant for the portfolio-manager whether she reinvests in  $j$  or in  $s$  assets. Country  $j$  would thus not be affected by the shock in country  $k$ . Nevertheless, this can not be stated from the equation.

In the previous example,  $k$  has a relatively strong impact in comparison to  $j$ . Therefore, the curve is very steep.

An extension to more than three assets is straightforward as will be shown in the next section. In that case we would have to find points inside an area of a hyper-space. Before continuing it is helpful to summarize the key findings of the previous section.

A specific VaR-model would tell the portfolio manager in a mechanistic fashion what should be done in different situations. Nevertheless, deciding which variables changed by how much, i.e. the 'inputs' of the model, depend on the knowledge and experience of the portfolio manager. Therefore, people managing identical portfolios through VaR might have different views on marketplace changes and so, undertake different changes on their portfolio.

Furthermore, the formal analysis showed that, although financial crisis always lead to portfolio losses when regarding only long positions, its roots might be different. The VaR-model calls for different reactions in accordance to the reason of the losses. Financial crisis might lead to capital outflows or inflows in the affected country or countries next to it. The result is not clear-cut.

One surprising result might be the reaction to a currency crises. A depreciation of a currency results in a massive reduction of VaR. Therefore, the portfolio manager needs to reduce the holdings of some other risky assets. From VaR one does not know if this will be highly correlated assets. As we will see in the next section one could set a rule aiming at a minimization of transactions costs. So, the assets with the strongest impact on the portfolio VaR would be sold. We will call this impact the VaR-elasticity.

In the next section, we use data of portfolio positions of international banks before the Asian currency crisis to compute the reaction VaR would call for and compare this with the true reactions of different investors.

## V Estimates of VaR Reactions during the Asian Crisis

As a starting point we use BIS data of emerging markets portfolio holdings of international banks on the eve of the devaluation of the Thai Bath. Then we calculate the change in the VaR for the three types of events and give an estimate for the possible magnitude of capital flows from banks due to portfolio re-balancing.<sup>16</sup> Finally, we compare the estimated flows with the actual changes in positions as reported to the BIS.

### *Data*

We use BIS data on consolidated international claims by nationality and construct a country-portfolio of holdings in emerging markets for the five largest banking centers (in percent of developing country claims in June 1997):<sup>17</sup> Japanese banks (who held 28 percent), the German banks (who held 21 percent), French (11 percent), US-American (11 percent) and British investor (10 percent). In addition we consider a “world investor”, that is the portfolio holdings in developing countries of all 18 banking centers which report to the BIS.

We only take into account emerging markets which account for at least 1 percent of invested funds. In other words, countries in which none of the five investors has invested at least

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<sup>16</sup> Note that this is a maximum estimate of the impact of VaR's since we are assuming that banks use VaR to allocate their entire portfolio holding.

<sup>17</sup> The data include lending through banking offices located outside the reporting area, but of the same nationality as countries in the reporting area. The data cover all on-balance sheet claims on countries outside the reporting area, including deposits and balances placed with banks, loans and advances to banks and non-banks, holdings of securities, and participation. The data include local claims of affiliates in outside-area countries in non-local currency, as well as net asset positions in local currency. Also, Investment banks are generally covered.

this 1 percent have been kept out of the analysis. Following this rule 22 different emerging countries are taken into account.<sup>18</sup>

*Table 2: Portfolio Holdings (in bnUS dollars)*

	World	Japan	Germany	USA	France	UK
Total	1461	405	301	161	159	148
Of World (%)	100.00%	27.70%	20.61%	11.04%	10.87%	10.10%
Greece	38.21	2.87	4.81	2.58	3.57	3.62
Portugal	30.97	0.70	5.96	0.97	2.77	1.34
Turkey	25.06	2.10	5.66	3.02	3.32	1.23
Russia	69.08	0.80	29.88	7.54	4.89	0.58
Czech Republic	11.38	0.98	5.55	0.59	0.83	0.24
Hungary	10.85	1.11	5.10	0.58	0.34	0.21
Poland	8.91	0.14	1.90	1.27	0.52	0.56
Argentina	44.84	1.60	7.62	9.94	3.73	2.72
Brazil	71.86	4.92	8.54	15.96	7.38	4.54
Chile	17.57	1.34	2.62	3.99	0.95	0.44
Colombia	17.00	1.33	1.98	3.37	1.24	1.13
Mexico	62.16	4.59	5.55	17.63	5.45	4.93
Venezuela	12.07	0.37	1.35	3.12	0.95	1.19
Australia	53.87	15.87	6.04	5.78	3.34	7.66
New Zealand	12.35	2.07	1.24	1.18	0.29	2.80
China	57.92	18.73	7.28	2.93	7.30	6.91
Philippines	14.44	2.11	1.99	2.81	2.01	1.08
Indonesia	58.73	23.15	5.61	4.59	4.79	4.33
Taiwan	25.16	3.01	3.00	2.51	5.15	3.16
Malaysia	28.80	10.49	5.72	2.38	2.93	2.01
Korea South	104.15	23.73	10.79	9.96	10.79	6.06
Thailand	69.38	37.75	7.56	4.00	5.09	2.82

Table 2 shows the portfolio holdings on the eve of the Asian crisis of the five largest banking centers as well as the world investor in 22 emerging markets. The additional necessary information in order to compute the VaR is the 22x22 variance/covariance matrix of the assets. This has been constructed by using Datastream data on stock indexes of the respective countries. To compute the June variance/covariance matrix available data only until 1.6.97 has been used

<sup>18</sup> The entire BIS data includes 188 countries. Although the sum of the investments not regarded is therefore considerable, the investments in each one of these countries is often extremely small and always below 1%.

and for the January matrix data only until 1.1.98. This allows to replicate the information available to investors at the time.

*Impact on VaR for the three types of events*

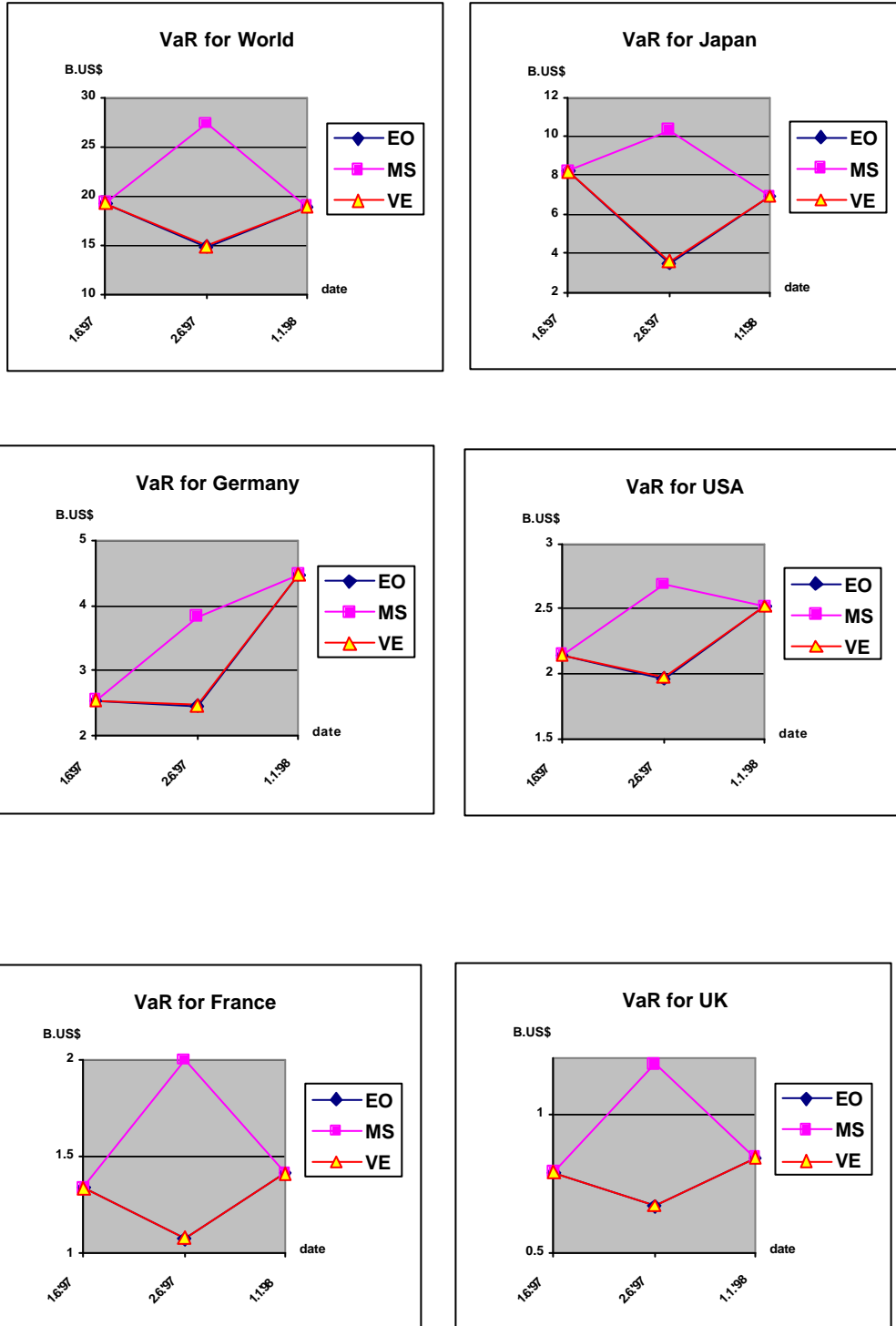
On June 1997 the Thai stock market fell by more than 20 percent in US dollars in half a month. By end of 1997 the Thai stock market had lost 63.8 percent of its value in US dollars terms. The interesting questions is: what happened to the VaR of the five largest banking centers after the Thai shock? Assume that the loss on Thai assets occurred all at once on 2. June 1997 resulting in a decline of Thai shares by 63.8 percent. We then calculate the new VaR for each investor under different assumptions about the loss event causes (denoted as 2. June 1997 (E.O.) where the term in the bracket stands for 'extreme observation', (M.S.) stands for man shift and (V.E.) stands for volatility event).

*Table 3.: VaR at different points in time (in bn US dollars)*

	<i>World</i>	<i>Japan</i>	<i>Germany</i>	<i>USA</i>	<i>France</i>	<i>UK</i>
Ex ante VaR 1.6.97	19.25	7.77	2.55	2.14	1.34	0.79
VaR 2.6.97 (E.O)	14.79	3.47	2.46	1.96	1.08	0.67
VaR 2.6.97 (M.S.)	27.35	12.54	3.83	2.69	2.00	1.18
VaR 2.6.97 (V.E.)	14.89	3.57	2.47	1.97	1.08	0.67
VaR 1.1.98	18.87	6.91	4.47	2.52	1.41	0.84

Note: VaR of 1.6. 97 and 1.1.98 are actual VaR's calculated from bank positions as reported to the BIS. VaR's for 2. June 1997 are calculated assuming the Thai shock).

Figure 3: VaR at different points in time (in bn US dollars)



Figures 3 are a graphical representation of the changes of the VaR from the actual on July 1, 1997 to the simulated ones for July 2, 1997 and, again, the actual on January 1, 1998. For instance, before the currency crisis the VaR of all industrialized countries international banks (our World Investor) was 19.25 billion US dollars.

The first simulated VaR of July 2, 1997 uses the assumption of an extreme observation. In this scenario, the investor presumes that the loss event in Thailand is one of the five percent unusually high losses. Following the loss the VaR diminished to 15 bn US dollars (for the World Investor).

The second simulated VaR on July 2, 97 is the mean shift event. Assume that investors do believe that the entire distribution of returns has shifted, they expect the Bath to continuously depreciate loosing up to 50 percent of its value, i.e. the earnings on the Thai shares will halve.<sup>19</sup> As shown in section 4.2. each investors' VaR deteriorates by the (remaining) asset share times the future expected loss. Under these assumptions, the World Investor faces a much higher Value at Risk, namely 27 bn US dollars). This is the net change in VaR after accounting for the extreme observation and a mean shift event.

Finally, the third VaR represents the volatility event . In this case, the investor assumes the shock to arise from a rise in the volatility of the Thai share (which the historical data does not account for). In fact, the variance of the Thai stock market steadily increased beginning on May 1997 (variance: 0.53) until approximately June 1999 (variance: 1,00), i.e. increased by approximately 85 percent. The increase during the 2<sup>nd</sup> semester of 1997 was approximately 25 percent. Assuming the investor forecasts correctly this increase by 25 percent in the variance and following the approach in section 4.3. (however for a 22 assets case) we find that the VaR 2.6.97 (V.E.) decreases to about 15 bn US dollars. This is again the net result after accounting for the extreme observation and the volatility event. The increase in volatility marginally improves the portfolios VaR.

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<sup>19</sup> In fact, the Thai Bath suffered a loss of 63 percent from midst June 1997 to midst January 1998.

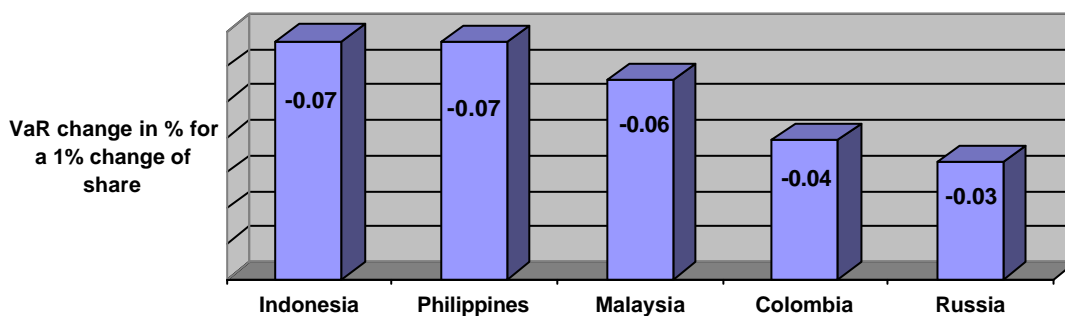
*Magnitude of capital flows from banks due to portfolio re-balancing*

We now turn to estimate the capital flows that would be induced by portfolio re-balancing following the shock to the portfolio.

The last section showed a significant change (positive or negative) in the VaR following the initial shock. Under the assumption that the initial level of VaR was optimal the portfolio needs to be re-balanced to return to the original level. This could be achieved through many different combinations of sales, yet it is sensible for the portfolio manager to sell those assets first which have the strongest (negative) impact on VaR in order to minimise transactions. This 'impact' can be computed: it is the derivation of percent VaR ( $R^*$ ) by the change in the respective asset share. We will call the resulting coefficient the 'VaR elasticity' of the asset. This elasticity tells by how much percent the VaR will decrease if one percent of the portfolio value is sold of a specific asset.

Using the data available to the portfolio manager until 2<sup>nd</sup> of June 1997 these elasticity's have been computed for world.<sup>20</sup> Figure 4 shows the values for the five countries with the highest elasticity's.

*Fig. 4: The five countries with the highest VaR elasticity's to world*



Note that only data that was available at the time until June 1997 has been used to compute the respective elasticity's. Note also that some of the countries which had the highest VaR elasticity's were among the most adversely affected by the Thai crisis in the following months. These findings point to the impact VaR readjustment had on transmitting financial instability around the world.

Next, using the sales rule described above, we compute the specific necessary capital flows in order to return to the original VaR level. In doing so, we will have to differentiate among the three kinds of events: extreme observation, mean shift and volatility event. We will present the results for these three cases for the 'world investor'. The corresponding flows for the five countries are presented in the appendix.

*Reaction to a Extreme Observation Event:*

From table 3 we can see that the VaR decreased from 19 bn US dollars to 15 bn US dollars. The portfolio involves less risk after the Thai crisis as the share of a risky asset has declined significantly and there is no need for adjustment from the point of view of risk. Still, if the former portfolio was optimal then the resulting shares of countries deviate from this optimum. The Thai share is too low and all other shares are slightly too high. In order to perform the necessary purchase a small part of all other shares ought to be sold. For the case of world-investor 43 bn US dollars of the Thai share would be bought. The biggest sales of other shares would take place for South Korea (change in VaR: -1.7 bn US dollars), Brazil and Russia (change in VaR: -1.2 bn. US dollars), Mexico and Indonesia (-1 bn. US dollars). The complete table for world and for the other investor countries is presented at the appendix.

*Reaction to a Mean shift event:*

For the case of the mean shift event the VaR has increased considerably. In the case of 'world' the VaR rose from 19.25 bn. US dollars to 27.35 bn. US dollars. In order to return to the

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<sup>20</sup> The values for all countries for world and the five other investing countries can be found in the appendix in table 1.

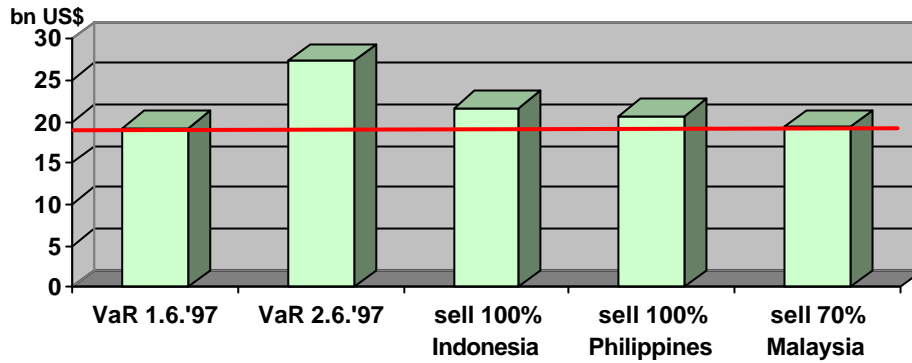
original VaR level, we assume the investor to sell those shares first with the biggest impact on VaR, i.e. those with the highest VaR elasticity's.<sup>21</sup> Under this assumption, the world investor would sell the entire Indonesian assets (sell 4.09 percent of portfolio value which amount to 59 bn. US dollars, VaR decreases by 5.6 bn. US dollars from 27.3 bn. US dollars to 21.7 bn. US dollars), sell the entire Philippine assets (sell 1.01 percent of portfolio value which amount to 14 bn. US dollars, VaR decreases by 1.1 bn. US dollars from 21.7 bn. US dollars to 20.6 bn. US dollars) and sell 70 percent of the entire Malaysian assets (1.4 percent of portfolio value which amount to 20 bn. US dollars, VaR decreases by 1.3 bn. US dollars from 20.6 bn. US dollars to 19.3 bn. US dollars). Figure 5 shows this result graphically. The initial increase in VaR stems from the asset price shock (extreme observation) and the investors believe that the currency will depreciate subsequently (mean shift event). The following VaR decreases result from the necessary re-balancing, i.e. the sales of assets with highest VaR-elasticity's. The fat line represents the maximum permissible VaR level which needs to be attained after the re-balancing took place.<sup>22</sup>

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<sup>21</sup> One problem of the presented approach is that all elasticity's will change at the moment one dollar of any asset is sold. Using constant elasticity's as sales-rule results in selling all of the asset holdings of some countries and none of some others. Obviously, this is not realistic. The more one sells of one asset the lower the effect on VaR will be as the loss of the diversification advantages become more and more noticeable. Therefore, although the capital flows might be overestimated using this method they do give a rough idea of the direction and magnitude of the necessary flows.

<sup>22</sup> The presented re-balancing result in a VaR roughly equal to the one before the Thai crisis in US dollars. Another approach would be to adjust the portfolio until the same VaR in percent is achieved. In this case additional sales would be necessary. Instead of selling 70% of the Malay assets (20 bn US dollars) 95% would be sold (27 bnUS dollars). The reason is the following. Trying to adjust the VaR in percent accounts for the capital loss and the diminishing of the total portfolio value due to the loss of the Thai holdings. A smaller portfolio having the same VaR in dollars as before will obviously be more risky (have a higher VaR in percent).

*Fig. 5: Returning to former VaR-level*



*Volatility event reaction:*

Looking at the results in table 3 one can see that the volatility event has almost no effect on VaR. If a portfolio manager believes the Thai crisis to have been a volatility event then the extreme observation impact will predominate. The necessary reaction is equivalent to the one of the extreme observation case. Still, this event might be of relevance for a crisis where different shares suffer a variance increase as in fact took place. Nevertheless, the aim of this paper is to look at a shock on one single asset. Therefore, we will not further pursue the volatility event.

*Estimated versus actual changes in positions*

Finally, we confront our estimates of capital flows with the actual changes in positions of international banks.

It should be said at the outset, that data availability constraints are a severe limitation in this exercise. The BIS data by nationality of lender is available only at six months intervals, whereas the time horizon for VaR models is typically very short. Ideally, we would have the positions of

international banks in the immediate aftermath of the shock.<sup>23</sup> Countering this concern is the fact that not all claims of banks are liquid and so, cannot be sold immediately. Another caveat is, that during that half year other shocks to other countries followed which are not modelled here.

Table 4 shows the flows of the computed 2<sup>nd</sup> of June portfolio to the January portfolio in billions of US dollars. The first column shows the actual change in positions of banking systems between July 97 and January 98.<sup>24</sup> The E.O. column shows the necessary flows implied by the 'extreme observation' case in order to regain the original VaR level. The M.S. indicates the movements implied if the investor believes the shock to be a mean shift event (due to a currency crisis). One would need to sum up the E.O. and M.S. flows if they are assumed to take place simultaneously. The volatility event has not been listed separately because the flows implied are too little. The last line presents the outflows of 'cash'. A negative outflow would mean that the investors cash position worsened, i.e. she decided to use additional capital in order to buy assets. A positive outflow means that the investor sold asset and took this capital out of the portfolio. The positive outflows might probably represent a shift to home assets.

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<sup>23</sup>

<sup>24</sup> In order to make the different columns comparable the Thai shock has been implemented, i.e. the Thai assets are smaller by 63.8 % compared to original BIS data.

*Table 4.: Estimated Capital Flows induced by Portfolio Re-balancing  
In order to achieve the Pre-Shock VaR following an  
extreme observation E.O. event and a mean-shift event  
(in bn US dollars)*

	World			Japan			Germany			USA			France			UK		
	actual	E.O.	M.S.	actual	E.O.	M.S.	actual	E.O.	M.S.	actual	E.O.	M.S.	actual	E.O.	M.S.	actual	E.O.	M.S.
Greece	1.02	-0.72		0.04	-0.29		1.06	-0.14		-0.54	-0.14		0.90	-0.43		1.42	-0.29	
Portugal	0.35	-0.57		0.09	-0.14		0.63	-0.29		-0.28	-0.14		-0.33	-0.29		-0.09	-0.14	
Turkey	4.19	-0.43		0.08	-0.29		0.96	-0.29		0.57	-0.29		0.48	-0.29		0.14	-0.14	
Russia	3.09	-1.15		0.19	-0.14		0.58	-1.29	-4	-0.47	-0.57		2.08	-0.57		0.38	0.00	
Czech Rep.	-0.59	-0.14		-0.16	-0.14		-0.52	-0.29		0.01	0.00		0.10	-0.14		-0.03	0.00	
Hungary	0.37	-0.14		-0.23	-0.14		0.16	-0.29		-0.15	0.00		0.06	0.00		0.27	0.00	
Poland	0.60	-0.14		0.19	0.00		0.17	-0.14		-0.48	-0.14		0.08	0.00		0.24	0.00	
Argentina	15.58	-0.72		0.00	-0.14		0.96	-0.29		0.59	-0.86		1.74	-0.43		3.40	-0.14	
Brazil	4.50	-1.29		0.06	-0.57		2.17	-0.43		-0.15	-1.29		1.25	-0.72		0.02	-0.29	
Chile	3.61	-0.29		-0.13	-0.14	-4.88	0.46	-0.14		0.67	-0.29		0.37	-0.14		0.24	0.00	
Colombia	1.48	-0.29		0.17	-0.14	-4.88	0.20	-0.14		0.35	-0.29		0.17	-0.14		0.16	-0.14	
Mexico	-0.37	-1.01		0.09	-0.57		0.24	-0.29		-1.00	-1.44		0.32	-0.57		0.60	-0.29	
Venezuela	0.17	-0.14		-0.06	0.00		0.25	0.00		0.48	-0.29		-0.22	-0.14		-0.07	-0.14	
Australia	-1.11	-0.86		0.07	-2.01		0.67	-0.29		-0.89	-0.43		-0.33	-0.29		-0.91	-0.57	
New Zealand	-1.33	-0.14		-0.69	-0.29	-7.61	-0.13	0.00		-0.23	-0.14		0.04	0.00		-0.73	-0.14	
China	5.31	-1.01		0.86	-2.30		0.61	-0.29		-0.40	-0.29		0.90	-0.72		1.29	-0.43	
Philippines	5.29	-0.29	-14.51	0.52	-0.29	-7.76	1.01	-0.14	-9.62	0.42	-0.29	-12.64	0.15	-0.14	-18.38	0.53	-0.14	-10.48
Indonesia	-0.35	-1.01	-58.74	-1.14	-2.87	-85.03	0.56	-0.29	-27.00	0.31	-0.43	-41.22	-0.01	-0.57	-43.81	0.16	-0.29	-42.51
Taiwan	1.03	-0.43		0.51	-0.43		-0.33	-0.14		-0.32	-0.14		0.36	-0.57		-0.13	-0.14	
Malaysia	-1.27	-0.43	-24.42	-1.94	-1.29	-38.49	1.48	-0.29		-0.59	-0.14		-0.05	-0.29	-26.86	0.00	-0.14	-14.79
Korea South	-9.94	-1.72		-3.45	-2.87		-1.18	-0.43		-0.43	-0.86		0.35	-1.15		0.86	-0.43	
Thailand	33.74	43.09		19.51	83.73		3.29	22.84		1.09	22.55		2.88	29.16		1.34	17.38	
Cash	-56.16	0.00	97.67	24.95	0.00	148.7	-20.20	0.00	40.62	-6.46	0.00	53.86	-23.10	0.00	89.05	-20.35	0.00	67.78

When comparing the predicted figures with the actual portfolio readjustments there appears to be little correspondence. The main feature that the models seem to capture were the inflows into Thailand. The model predicts outflows from all countries which is consistent with the short term pressure experienced by most emerging markets, however, this is mostly not matched by the actual long run change in positions. The most likely interpretation of this difference between predicted and actual flows is that the time frames are simply too different and that some short run outflows may have later been reversed as events unfolded. Obviously, between the onset of the Thai crisis and the following sixth months, investors performed massive re-arrangements in their portfolios.

Still, some findings are noteworthy. According to the model mainly three countries are heavily affected by the Thai crisis: Indonesia, Philippines and Malaysia. Huge outflows of capital should have taken place according to presented theory. Despite the lack of data right after the crisis it is obvious that these outflows are over-estimated in our model. As argued before, one reason is the use of a linearized model with constant elasticity's. Using variable elasticity's will lead to a much more diversified sales of shares. A second reason can be differences in portfolio manager views. The computed outflows would only, in theory, take place if all investors agree that the Thai crisis has to be viewed as a shift in the distributions mean by 50%. Although the movements might be over-estimated the direction and countries from where they come is correctly captured by our model. The countries most strongly and directly affected by the Thai crisis according to the model are those which have been affected in reality as well. Furthermore, there are some countries which appear to have suffered, although only by a little, from the crisis. In a recent paper it is stated that even New Zealand and Australia might have been affected by the crisis<sup>25</sup>. Such contagion is detected for New Zealand by our model. Furthermore, we detect a slight impact on Russia, Chile and Colombia.

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<sup>25</sup> Ellis, Lucy and Lewis, Eleanor (1999)

## VI Conclusions

Using BIS data of the end-June 1997 and end-December 1997 portfolio holdings of international banks we estimate the impact that VaR models might have on international capital flows. We 'shocked' the portfolios by a shock roughly resembling the Thai crisis and estimated the possible reactions investors using VaR methodology. One of the key findings is that if the Thai crisis is simply thought of as an extreme observation but nothing else then no contagion should have happened. This would decrease VaR, i.e. the portfolio would become less risky. The portfolio-manager would not need to react. And if she does, the sales of other assets (in order to re-buy the lost Thai shares) would be small and affecting all countries by roughly the same magnitude.

In addition, investors might think that some fundamental change took place in the distribution of the Thai asset. An increase in its volatility would increase VaR but only by a very small amount. This cannot be the reason for the observed contagion. On the other hand, one could think of a shift in the distribution mean. This could take place if an investor assumes a steady depreciation of the Thai Bath following the initial loss. In this case the VaR would increase dramatically and investors' would be forced to undertake massive shifts in assets. Assuming that investors correctly anticipate the Thai currency depreciation the VaR increases by about 50 percent for our five investing countries.

Next, we defined a sales rule: assuming that investors start selling those assets which have the highest impact on their VaR we calculate the 'VaR-elasticity' for each asset, i.e. each emerging market. We find that the countries with highest elasticity's are Indonesia, Philippines and Malaysia, countries that did suffer currency crisis. Following the sales rule, these countries assets will be sold first. We then compute the necessary sales for each investor in order to re-establish their former VaR. We find that the capital flows induced by VaR readjustment may be significant and in some cases certainly large enough to cause a currency crisis. Moreover, the model seems to predict quite accurately which countries were most likely to suffer from pressure on their currencies. Interestingly enough, these would have been the countries most affected even

if the initiating shock stemmed from any other circumstance or country So, it has little to do with their covariance to the Thai market.

Note that the outflow estimates are computed for homogenous investors, that is investors who use the same VaR model and share the expectations of a mean shift event. In this case the use of VaR models would indeed contribute to the international transmission of financial shocks. If, on the other hand, investors have differing views on the implication of the initial shock (and use different models) some may buy certain assets while others would sell these same assets. This suggests that a higher diversity of views and risk management methods would attenuate the systemic risk due to portfolio re-balancing.

### Appendix

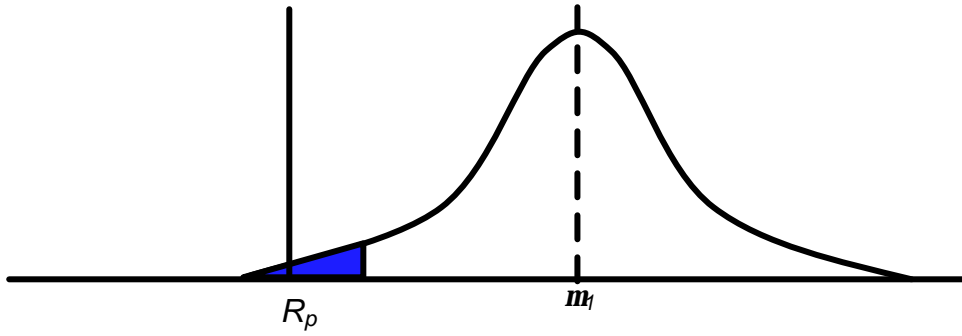


Figure 1: The extreme observation event

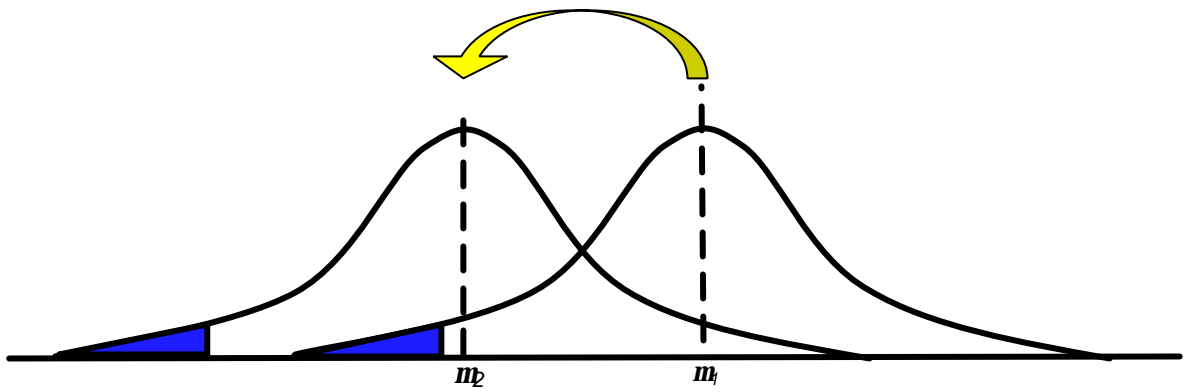


Figure 2: The mean shift event

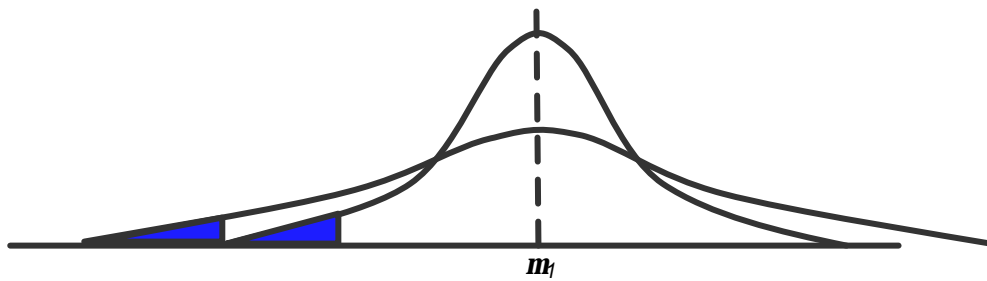


Figure 3: The mean shift event

*Table 1: VaR Elasticity's June 1997*


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	World	Japan	Germany	USA	France	UK
Greece	<b>0.45%</b>	<b>0.30%</b>	<b>0.47%</b>	<b>0.45%</b>	<b>0.36%</b>	<b>0.29%</b>
Portugal	<b>1.11%</b>	<b>0.34%</b>	<b>1.02%</b>	<b>1.11%</b>	<b>0.89%</b>	<b>0.71%</b>
Turkey	<b>0.97%</b>	<b>0.89%</b>	<b>0.81%</b>	<b>0.89%</b>	<b>0.81%</b>	<b>0.65%</b>
Russia	<b>3.29%</b>	<b>0.94%</b>	<b>4.48%</b>	<b>3.69%</b>	<b>2.71%</b>	<b>2.22%</b>
Czech Rep.	<b>0.30%</b>	<b>0.26%</b>	<b>0.34%</b>	<b>0.26%</b>	<b>0.23%</b>	<b>0.20%</b>
Hungary	<b>2.59%</b>	<b>1.61%</b>	<b>2.69%</b>	<b>2.79%</b>	<b>2.08%</b>	<b>1.62%</b>
Poland	<b>1.68%</b>	<b>0.43%</b>	<b>2.10%</b>	<b>2.28%</b>	<b>1.32%</b>	<b>1.12%</b>
Argentina	<b>1.82%</b>	<b>1.22%</b>	<b>1.56%</b>	<b>2.25%</b>	<b>1.45%</b>	<b>1.17%</b>
Brazil	<b>1.23%</b>	<b>0.44%</b>	<b>1.45%</b>	<b>1.69%</b>	<b>1.10%</b>	<b>0.92%</b>
Chile	<b>2.73%</b>	<b>3.17%</b>	<b>1.52%</b>	<b>2.35%</b>	<b>2.23%</b>	<b>1.85%</b>
Colombia	<b>3.90%</b>	<b>3.60%</b>	<b>1.73%</b>	<b>5.10%</b>	<b>3.08%</b>	<b>2.61%</b>
Mexico	<b>0.61%</b>	<b>0.00%</b>	<b>0.45%</b>	<b>1.46%</b>	<b>0.49%</b>	<b>0.37%</b>
Venezuela	<b>0.39%</b>	<b>1.68%</b>	<b>1.49%</b>	<b>1.73%</b>	<b>0.20%</b>	<b>0.14%</b>
Australia	<b>1.74%</b>	<b>1.53%</b>	<b>1.48%</b>	<b>1.64%</b>	<b>1.41%</b>	<b>1.14%</b>
New Zealand	<b>3.18%</b>	<b>3.03%</b>	<b>2.49%</b>	<b>2.89%</b>	<b>2.58%</b>	<b>2.12%</b>
China	<b>1.18%</b>	<b>0.11%</b>	<b>2.03%</b>	<b>1.20%</b>	<b>1.00%</b>	<b>0.69%</b>
Philippines	<b>6.68%</b>	<b>6.45%</b>	<b>4.93%</b>	<b>6.35%</b>	<b>5.43%</b>	<b>4.42%</b>
Indonesia	<b>6.71%</b>	<b>6.07%</b>	<b>5.48%</b>	<b>6.41%</b>	<b>5.40%</b>	<b>4.44%</b>
Taiwan	<b>2.29%</b>	<b>1.85%</b>	<b>1.92%</b>	<b>2.35%</b>	<b>1.89%</b>	<b>1.50%</b>
Malaysia	<b>5.60%</b>	<b>5.29%</b>	<b>4.33%</b>	<b>5.33%</b>	<b>4.56%</b>	<b>3.72%</b>
Korea South	<b>0.79%</b>	<b>1.54%</b>	<b>0.25%</b>	<b>0.62%</b>	<b>0.67%</b>	<b>0.61%</b>
Thailand	<b>4.92%</b>	<b>8.08%</b>	<b>0.49%</b>	<b>3.83%</b>	<b>4.06%</b>	<b>3.60%</b>

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*Computed as the derivation of VaR (in %) by the specific share. See page 22 for the discussion.*

## References

- Bank of International Settlements (1999), "The BIS consolidated international banking statistics," various issues, [www.bis.org](http://www.bis.org).
- Bank of International Settlements (1996), "Overview of the Amendment to the Capital Accord to Incorporate Market Risks", Basle Committee on Banking Supervision, Basle
- Bank of International Settlements (2000), "Compendium of documents produced by the Basle Committee on Banking Supervision- Vol. II: Advanced Supervisory Methods", Basle Committee on Banking Supervision, Basle
- Beder, Tanya Styblo (1995), "VAR: Seductive but Dangerous", *Financial Analysts Journal*, Vol. 51, No. 5 (Sept./Oct.):12-24
- Calvo, Guillermo (1998), "Understanding the Russian Virus, With Special Reference to Latin America", mimeo
- Calvo, Guillermo (1999), "Contagion in Emerging Markets: When Wall Street is a Carrier", mimeo
- Calvo, Guillermo and Mendoza, Enrique (2000), "Rational Contagion and the Globalization of Securities Markets", *Journal of International Economics*, Vol. 51, No.1, June: 79-113
- Danielsson, Jon (2000), "The Emperor has no Clothes: Limits to Risk Modeling", paper presented at a Conference on Liquidity Risk, Rethinking Risk Management, Frankfurt am Main, June 30- July 1, 2000
- Ellis, Lucy and Lewis, Eleanor (1999), "The Response of Financial Markets in Australia and New Zealand to News about the Asian Crisis", Conference paper No. 8, 'International Financial Markets and the Implications for Monetary and Financial Stability', March 2000, Bank for International Settlement, Basle
- Folkerts-Landau David and Peter Garber (1998), "Capital Flows from Emerging Markets in a Closing Environment", *Global Emerging markets*, Vol. 1. No 3, London: Deutsche Bank

Jorion, Philippe (1997), "Value At Risk: The New Benchmark for Controlling Market Risk",  
Irwin Professional Publishing, Chicago-London-Singapore

Jorion, Philippe (1996), "Risk<sup>2</sup>: Measuring the Risk in Value at Risk", Financial Analysts  
Journal, Vol. ??, No. ? (Nov./Dec.):47-56

Kodres, Laura and Matthew Pritsker (1999), "A Rational Expectations Model of Financial  
Contagion," mimeo, May, IMF and Board of Governors of the Federal Reserve.

Masson, Paul (1998), "Contagion: Monsoonal Effects, Spillovers and Jumps between Multiple  
Equilibria," IMF Working Paper WP/98/142.

Masson, Paul (1998), "Contagion: Monsoonal Effects, Spillovers and Jumps between Multiple  
Equilibria," IMF Working Paper WP/98/142.

Schinasi, Garry J. and R. Todd Smith (1999), "Portfolio Diversification, Leverage, and Financial  
Contagion," IMF Working Paper 99/136 (October).

The Economist (1999), "The Price of Uncertainty", June 12

Van Rijckeghem Caroline and Beatrice Weder (2000): " Spillovers Through Banking Centers - A  
Panel Data Analysis " IMF Working Paper No 00/88.

J. P. Morgan, "RiskMetrics Technical Document" of J.P. Morgan.: <http://www.riskmetrics.com/>

Telser, Lester G. (1955), "Safety First and Hedging", Review of Economic Studies, Vol. 23, No.  
1:1-16