Apples and Oranges: the difference between the Reaction of the Emerging and Mature Markets to Crashes.

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Summary.

We study here the behavior of the eigenvalues of the covariance matrices of returns for emerging and mature markets at times of crises. Our results appear to indicate that mature markets respond to crashes differently to emerging ones and that emerging markets take longer to recover than mature markets. In addition, the results appear to indicate that the *second largest* eigenvalue gives additional information on market movement and that a study of the behavior of the other eigenvalues may provide insight on crash dynamics.

keyword. Covariance Matrix, Eigenvalues and Stock Crashes.

Introduction.

Recently, several studies have applied the concepts and methods of physics to the areas of economics and finance, particularly to the study the covariance (or correlation) between price changes (returns) of different stocks [e.g. Meric and Meric (1997), Kwapien et al. (2002), Keogh et al. (2003) and Kwapien et al. (2004)]. Thus far, the magnitude of the *maximum eigenvalue* of the correlation (or covariance) matrices for different sectors in one stock market index only, has predominantly been studied with no attention paid to the other eigenvalues. The differences in the current work are twofold; firstly, to highlight the information obtained from the subdominant eigenvalue as well as the dominant eigenvalue and study their behaviour. Secondly, to compare this for stock market indices for two different classes, namely emerging and mature markets.

Our objectives in this article are thus; **(a)** To study the distribution of the eigenvalues of the Covariance matrices for equal-interval sliding windows, including the week before the Crisis, together with those of Covariance matrices for windows, including both the week of the Crisis and a week after. This, in order

to see the qualitative difference between emerging and mature markets to crashes in term of the eigenvalues (the λ's). **(b)** To study the distribution of the ratio of the *largest* to the *second largest* eigenvalue of the Covariance matrices for sliding windows of equal sizes. This, we believe, a measure of the degree of agreement (or coherence) in agent views of the market.

The remainder of this paper is organized as follows: The method of estimating the Covariance matrices is described briefly below (Section 2), with data and results presented in Section 3. Our brief discussion and conclusions form the final section.

Covariance matrix estimation.

The Variance-Covariance matrix can be computed easily, using the following formula, (full details see Litterman and Winkelmann (1998)):

$$\sigma_{ij}^{T}(M) = (\sum_{s=0}^{T} \omega_{T-s} r_{i,T-s} r_{j,T-s}) / (\sum_{s=0}^{T} \omega_{T-s}) \quad (1)$$

Where $r_{(i,T)}$ is the return on the i^{th} market at date T and ω_T is the weight applied at date T over horizon M. In our study, we use weekly returns of stock market indices (i=13 indices and T=20 for emerging and i=14 indices and T=20 for major markets for our data) and each week, previous to the current, receives 90% of the weight of the following week (where ω_T=1) as suggested in e.g. Litterman and Winkelmann.

Data and Results.

The data used in the following analysis consists of the weekly prices of a set of thirteen **emerging** market indices and a set of fourteen **mature** market indices during the period from the second week of January 1997 to the third week of March 2003. As each market uses its local currency for presenting the index values, we use the weekly *returns* instead of the weekly prices, where the following formula applies: **Weekly Return = Ln(P_t/P_{t-1}),** where P_t and P_{t-1} are the closing prices of the index at week t and t-1 respectively. The Variance-Covariance matrices for overlapping windows of size 20 weeks have been calculated using Equation (1).

Empirical results.

Figures 1 and 2, for the emerging and mature markets respectively, show the distribution of the eigenvalues of the Covariance matrices for overlapping windows of size 20, before and after the Asian Crisis in July 1997, the Global

Crisis in October 1998, the Dot-Com Crash in March 2000 and the September the 11th Crash in 2001.

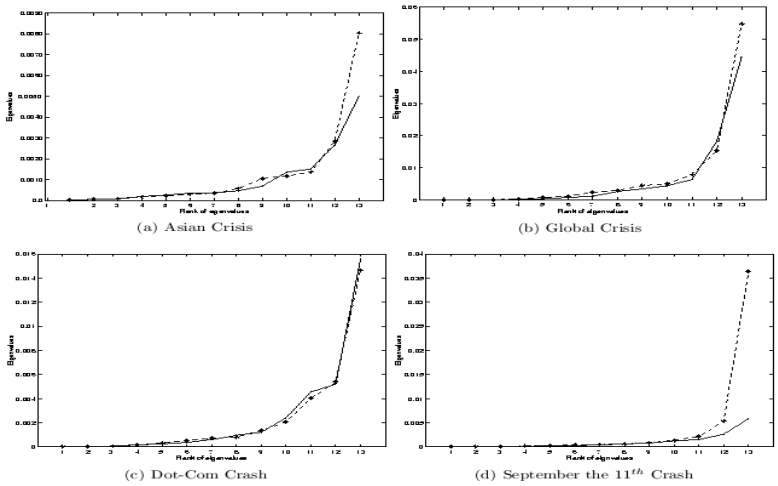


Fig. 1. The distribution of the eigenvalues of the covariance matrices before (**Solid line**) and after (**Dashed line**) the crash for Emerging markets[1].

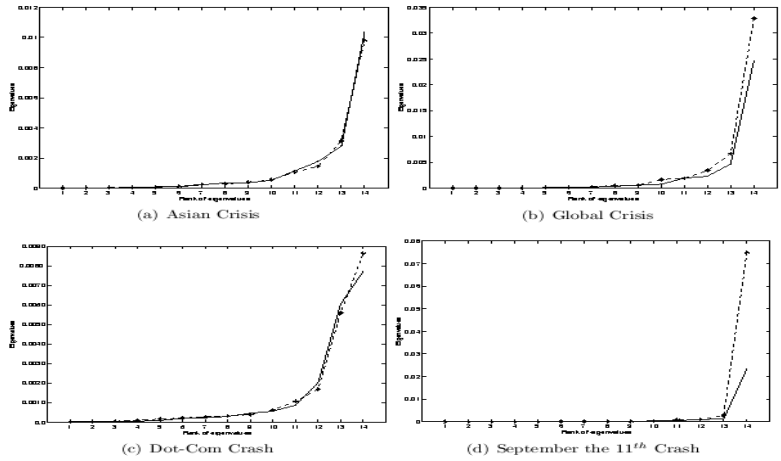


Fig. 2. The distribution of the eigenvalues of the covariance matrices before (**Solid line**) and after (**Dashed line**) the crash for Mature markets[1].

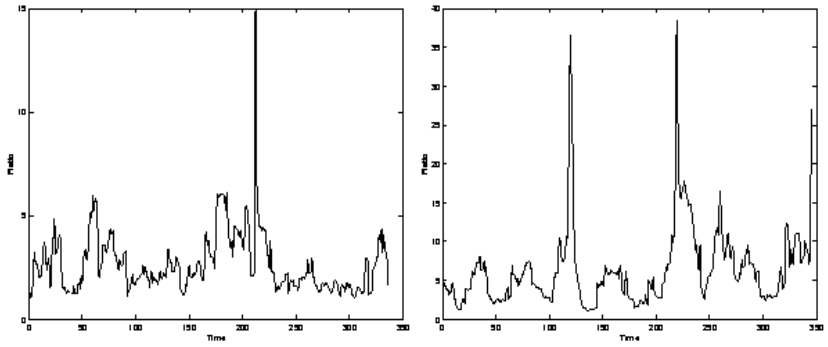
[1] In figures 1 and 2, the **Eigenvalues** are given on the **y-axis** while their **Ranks** are given on the **x-axis**.

Figures 1(a) and 2(a) show that the value of the maximum eigenvalue (λ_1) increased, for emerging markets, after the Asian Crisis, which began in July 1997 in Thailand, but did not change markedly for developed markets. This implies that the crisis mainly affected emerging markets but not the mature ones. However, Figures 1(c) and 2(c) show that the Dot-Com Crash influenced major markets but not emerging ones and took longer than a week to show a strong effect.

From Figures 1(b) and 2(b), we can see that the Global Crisis in 1998 affected emerging and mature markets comparably in the same week.

Figures 1(d) and 2(d) show that the value of λ_1 after the September 11th crash, which could not have been predicted by most people, hugely increased for **both** emerging and mature markets. This implies that stock markets around the world were hit very hard and that the markets moved in *coordination* to make a recovery after falling so sharply or being oversold.

The ratio of the *Largest* (λ_1) to the *Second Largest* (λ_2) eigenvalues of the Covariance matrices for emerging and mature markets are shown in Figures 3(a) and 3(b) respectively. These show a *qualitative difference* in the way emerging and mature markets deal with crises, (especially unexpected ones). For major markets, there are three highly significant points in the distribution of this ratio representing the third week of October 1999 (the 12th anniversary of the October 19 stock market crash)}, the second week of September 2001 *(9/11 crash)* and the third week of March 2004 *(Madrid Bomb)* respectively. However, for emerging markets, there is only one highly significant point representing the second week of September 2001 *(9/11 crash)*.



(a) Emerging Markets (b) Major Markets

Fig. 3. The distribution of ratio of *Dominant* (λ_1) to *Subdominant* (λ_2) eigenvalues of covariance matrices for equal overlapping time windows

The results also show that the mature markets move together immediately after the crash to bounce back faster than emerging markets. In other words, the recovery time from crisis for developed markets is shorter than that for developing ones.

Conclusion.

Our aims were to study the distribution of the eigenvalues of covariance matrices for emerging and mature markets at crisis points (namely, the Asian Crisis, Global Crisis, Dot-Com Crash and September the 11th Crash). In particular, we wished to distill the information from the ratio of the Largest to the Second Largest eigenvalues of these covariance matrices. Our findings can be summarized as follows: **(i)** The Asian Crisis in 1997 disproportionately affected the emerging markets compared to the major ones while the Dot-Com Crash influenced major markets but affected emerging ones far less. **(ii)** The Global Crisis in 1998 affected developing markets as much as developed ones in the same week. **(iii)** The September 11th Crash hit both emerging and mature markets very hard because it was totally unpredictable. **(iv)** The distribution of the ratio of λ_1 to λ_2 appears to show that emerging and mature markets deal with crashes differently especially unexpected ones. This means that mature markets move together immediately after the crash to bounce back faster than emerging markets. In other words, the recovery time from crisis for emerging markets is longer than that for mature ones.

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