New York
May 18, 1995

Morgan Guaranty Trust Company
Market Risk Research
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(1-212) 648-4317

RiskMetrics™ Data Sheet
Australian Dollar - Spot FX
From: 31-Dec-87 to: 26-Oct-94

JPMorgan

For Internal Use Only

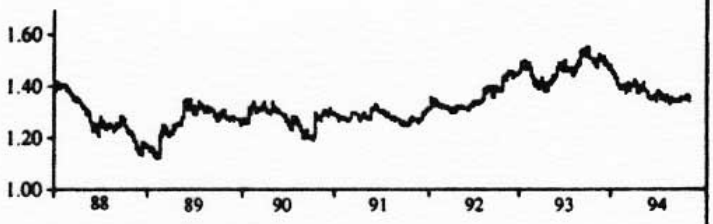
US$/AUD

Rates are mid-spot exchange rates captured at 4:00 P.M. London time (11:00 AM US EST). Source: MGT London data source until Dec 31, 1993; standard rates provided by WM Company and Reuters thereafter. All foreign exchange data used for RiskMetrics is identical to the data used in the J.P. Morgan family of Government Bond indices.

	Series	Daily % change
Range	0.431	5.669%
Minimum	1.121	-3.661%
Maximum	1.552	2.008%
Count	1780	1780
Mean	1.331	0.003%
Standard Deviation		0.566%
1.65 Standard Deviations		0.935%
Kurtosis		3.943
Skewness		-0.849
Correlation to Normal Distirbution		0.984

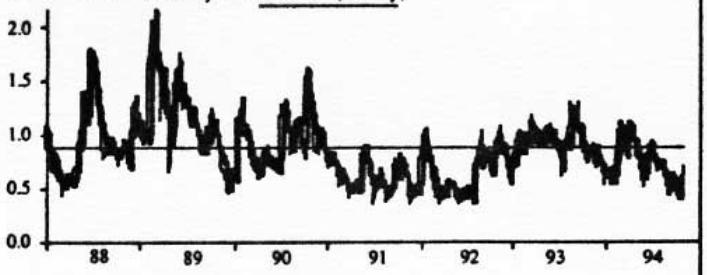
	Monthly % change
Range	17.930%
Minimum	-9.924%
Maximum	8.006%
Count	1755
Mean	0.099%
Standard Deviation	2.700%
1.65 Standard Deviations	4.456%
Kurtosis	0.547
Skewness	-0.317
Correlation to Normal Distirbution	0.991

Series history

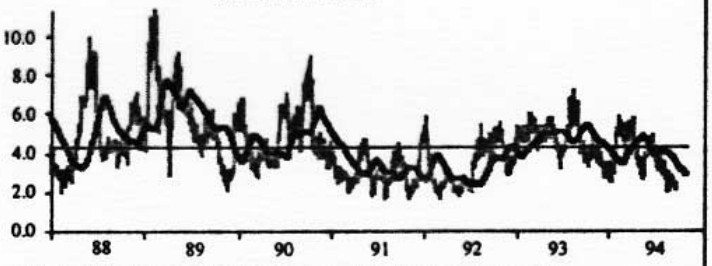


Volatility estimates (% of Price)

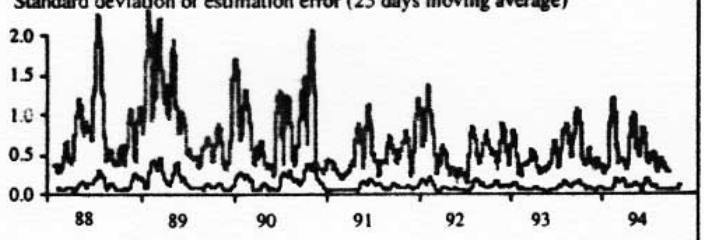
..vs. observed volatility for "current" (25 day)



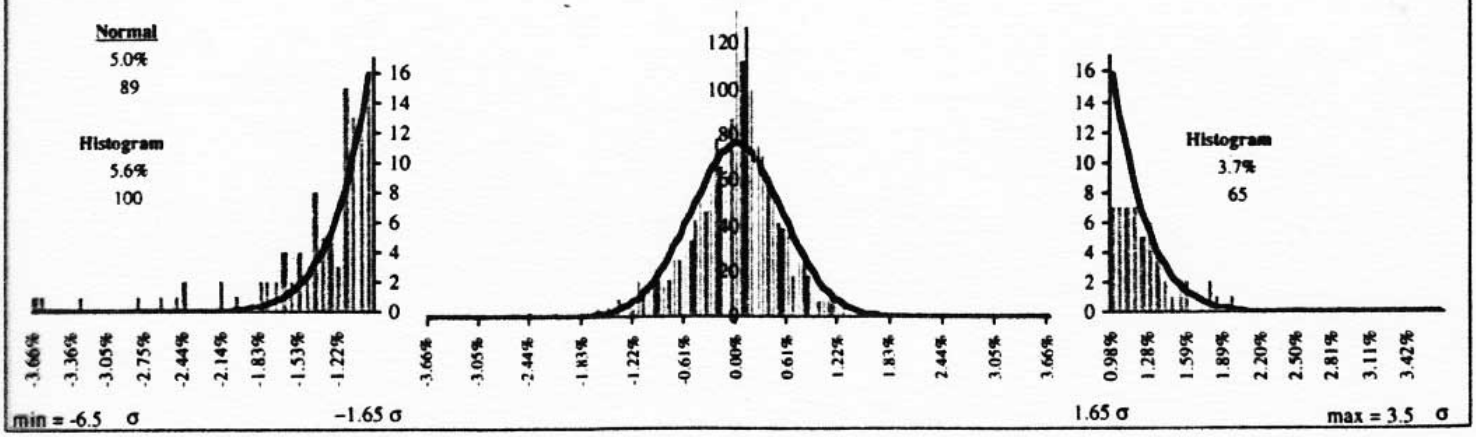
..vs. observed volatility over next month



Standard deviation of estimation error (25 days moving average)



Histogram of daily percent changes (Price)



AUD/US$
JPY/US$

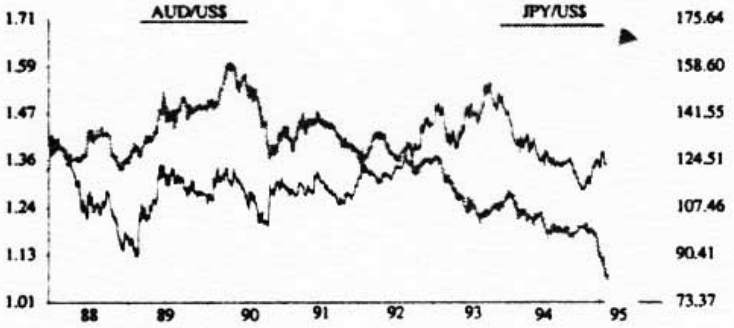
Summary statistics

Correlation	Daily	Monthly
Average	.13	.11
Range : Observed	-.64 to .85	-.64 to .85
Estimated	-.55 to .75	-.44 to .65

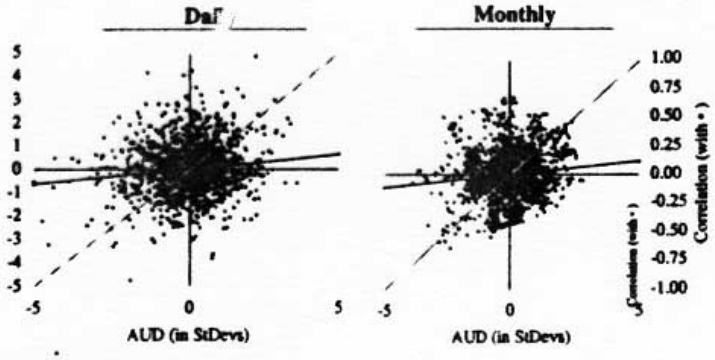
Percent Change	AUD	JPY	AUD	JPY
Range	5.72%	7.06%	18.15%	17.92%
Minimum	-3.73%	-3.45%	-10.45%	-8.02%
Maximum	1.99%	3.61%	7.70%	9.90%
Count	1903		1903	

Data Series		
Mean	1.33	125.18
Standard Deviation	0.083	16.191
1.65 Standard Deviations	.138	26.715
Kurtosis	-0.047	-0.635
Skewness	0.346	-0.302

Series history

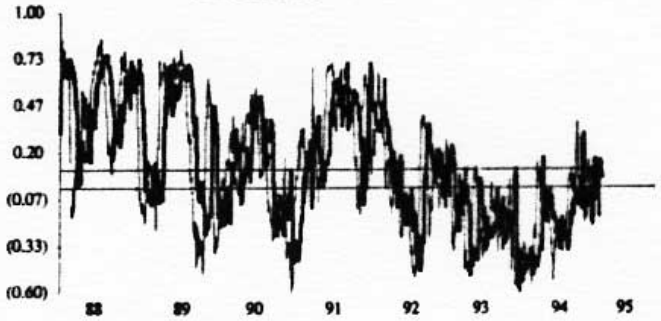


Scattergrams and correlation

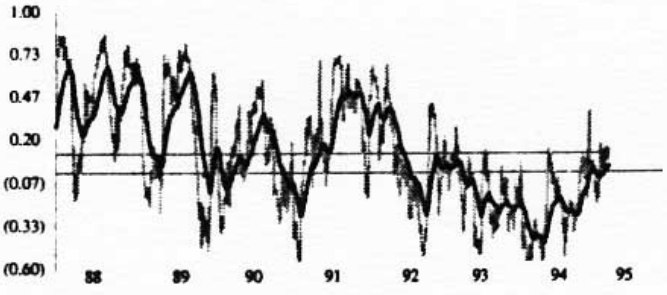


Correlations estimates

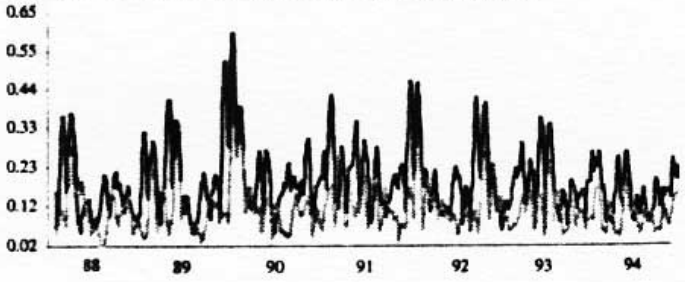
... vs. daily observed "current" (25 day) correlation



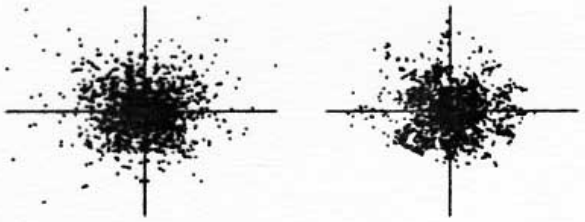
... vs. monthly observed correlations



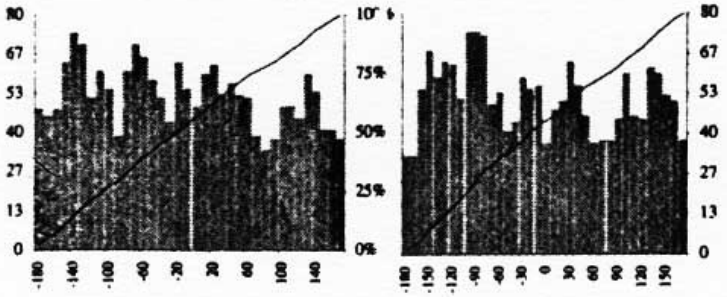
Standard deviation of estimation error (25 days moving average)



Transformation to circular form



Distribution of transformed angles



Distribution of transformed radii & chi distribution(2 degs of freedom)

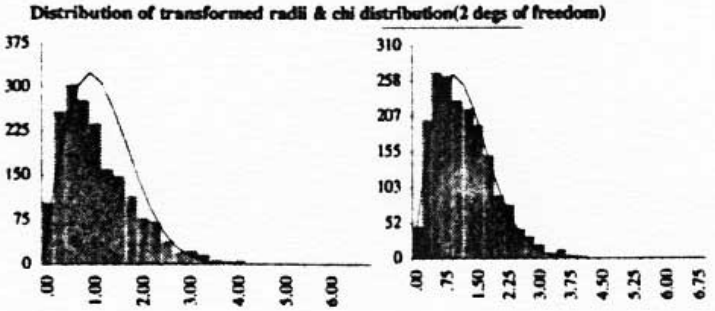


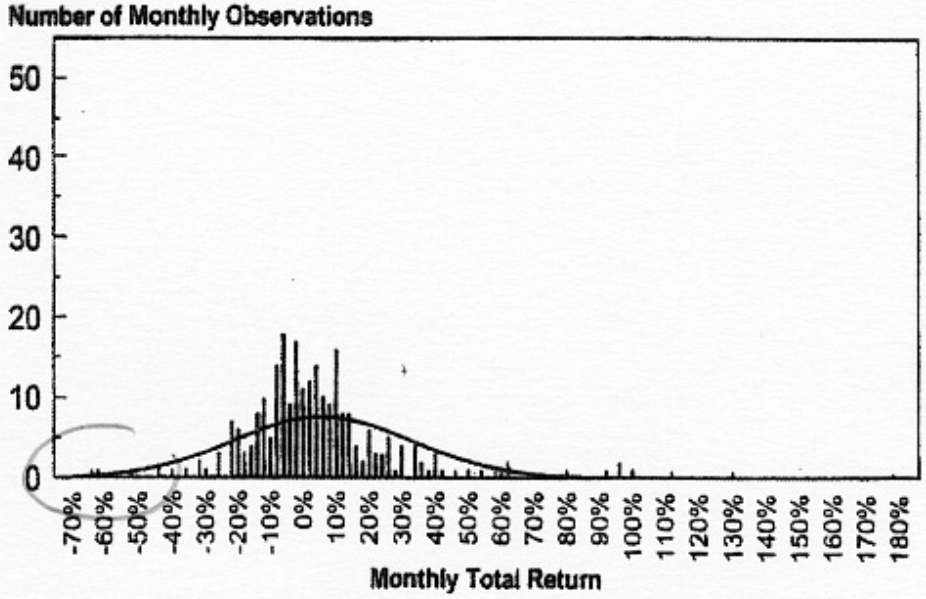
Table 1.1. Stock market returns, 1962 to 1994.

Security	Mean	Standard Deviation	Skewness	Excess Kurtosis	Minimum	Maximum
			Panel A: Daily Returns			
Value-Weighted Index	0.044	0.82	−1.33	34.92	−18.10	8.87
Equal-Weighted Index	0.073	0.76	−0.93	26.03	−14.19	9.83
International Business Machines	0.039	1.42	−0.18	12.48	−22.96	11.72
General Signal Corp.	0.054	1.66	0.01	3.35	−13.46	9.43
Wrigley Co.	0.072	1.45	−0.00	11.03	−18.67	11.89
Interlake Corp.	0.043	2.16	0.72	12.35	−17.24	23.08
Raytech Corp.	0.050	3.39	2.25	59.40	−57.90	75.00
Ampco-Pittsburgh Corp.	0.053	2.41	0.66	5.02	−19.05	19.18
Energen Corp.	0.054	1.41	0.27	5.91	−12.82	11.11
General Host Corp.	0.070	2.79	0.74	6.18	−23.53	22.92
Garan Inc.	0.079	2.35	0.72	7.13	−16.67	19.07
Continental Materials Corp.	0.143	5.24	0.93	6.49	−26.92	50.00
			Panel B: Monthly Returns			
Value-Weighted Index	0.96	4.33	−0.29	2.42	−21.81	16.51
Equal-Weighted Index	1.25	5.77	0.07	4.14	−26.80	33.17
International Business Machines	0.81	6.18	−0.14	0.83	−26.19	18.95
General Signal Corp.	1.17	8.19	−0.02	1.87	−36.77	29.73
Wrigley Co.	1.51	6.68	0.30	1.31	−20.26	29.72
Interlake Corp.	0.86	9.38	0.67	4.09	−30.28	54.84
Raytech Corp.	0.83	14.88	2.73	22.70	−45.65	142.11
Ampco-Pittsburgh Corp.	1.06	10.64	0.77	2.04	−36.08	46.94
Energen Corp.	1.10	5.75	1.47	12.47	−24.61	48.36
General Host Corp.	1.33	11.67	0.35	1.11	−38.05	42.86
Garan Inc.	1.64	11.30	0.76	2.30	−35.48	51.60
Continental Materials Corp.	1.64	17.76	1.13	3.33	−58.09	84.78

Summary statistics for daily and monthly returns (in percent) of CRSP equal- and value-weighted stock indexes and ten individual securities continuously listed over the entire sample period from July 3, 1962 to December 30, 1994. Individual securities are selected to represent stocks in each size decile. Statistics are defined in (1.4.19)–(1.4.22).

EXHIBIT 1
DISTRIBUTION OF RETURNS

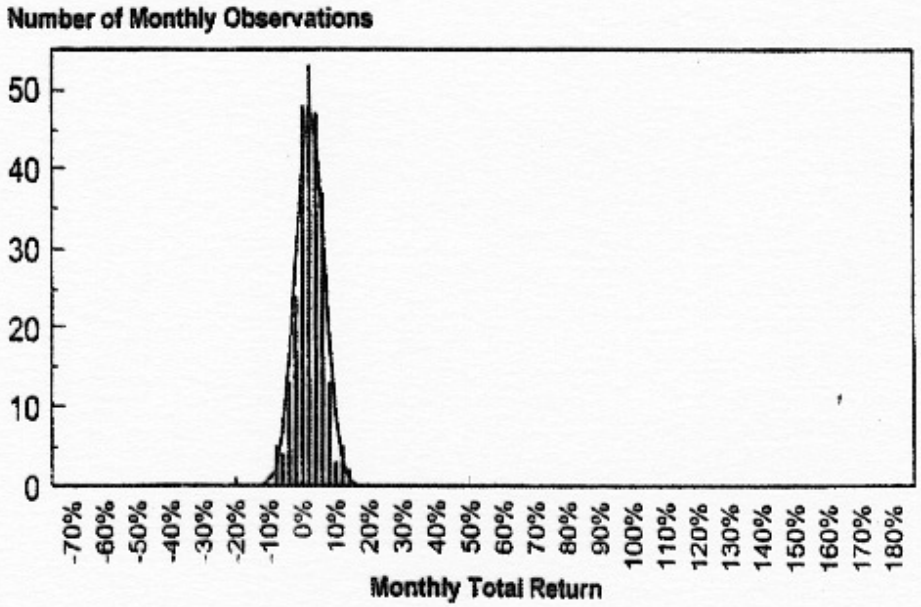
ARGENTINA



Monthly U.S. $ returns: January 1976-March 1997.

Source: International Finance Corp. Global Indexes.

UNITED STATES



Monthly U.S. $ total returns: January 1976-March 1997.

Source: Morgan Stanley Capital International.

EXHIBIT 2
SUMMARY STATISTICS

Country	Arith. Return (%)	Geometric Return (%)	Std. Dev. (%)	Skewness	Kurtosis	First-Order Autocorrelation	AC World	Corr. with: World	IFCG-CW	IFCG-EW
Time Period: April 1987-March 1997										
Argentina	56.8	27.2	87.9	3.32	20.22	–0.08	0.01	0.00	0.06	0.38
Brazil	42.6	22.1	63.9	0.25	1.09	–0.08	0.23	0.20	0.35	0.40
Chile	32.2	28.2	27.6	0.28	–0.07	0.29	0.19	0.16	0.48	0.46
Colombia	32.7	28.0	31.5	1.63	4.14	0.45	0.05	0.04	0.12	0.31
Greece	21.6	14.0	41.2	1.76	6.33	0.13	0.15	0.15	0.14	0.45
India	11.7	6.3	33.8	0.72	1.11	0.15	–0.09	–0.11	0.16	0.31
Jordan	5.9	4.6	15.9	0.17	1.53	–0.05	0.21	0.21	0.11	0.11
Malaysia	17.3	13.9	25.2	–0.86	2.79	–0.03	0.57	0.54	0.55	0.49
Mexico	29.2	17.2	45.4	–1.01	5.41	0.34	0.37	0.34	0.59	0.56
Nigeria	32.6	18.1	52.3	1.49	19.64	–0.02	0.05	0.05	–0.06	0.19
Pakistan	14.7	11.1	27.4	1.23	4.27	0.26	0.06	0.04	0.17	0.32
Philippines	23.4	17.7	34.1	0.67	3.69	0.21	0.34	0.32	0.36	0.43
Portugal	15.7	9.0	39.2	2.35	12.91	0.26	0.34	0.34	0.93	0.48
South Korea	6.6	2.8	28.0	0.59	0.42	–0.02	0.29	0.27	0.33	0.19
Taiwan	30.4	17.2	52.4	0.59	1.45	0.05	0.29	0.25	0.81	0.44
Thailand	20.5	15.0	32.7	–0.19	1.81	0.09	0.42	0.39	0.54	0.56
Turkey	41.9	19.7	70.5	0.97	1.04	0.15	0.06	0.05	0.28	0.49
Venezuela	23.9	12.9	46.9	0.25	2.23	0.12	–0.11	–0.10	–0.15	0.13
Zimbabwe	25.4	21.0	29.3	0.02	1.25	0.29	0.07	0.06	0.05	0.20
MSCI AC World	9.6	8.6	13.9	–0.75	3.08	–0.03	1.00	1.00	0.45	0.43
MSCI World	9.1	8.1	14.1	–0.69	2.86	–0.04	1.00	1.00	0.39	0.39
IFCG-CW	15.9	13.2	23.0	–0.46	1.88	0.18	0.45	0.39	1.00	0.71
IFCG-EW	25.3	23.8	16.1	0.09	0.84	0.30	0.43	0.39	0.71	1.00
Time Period: April 1991-March 1997										
MSCI AC World	12.7	12.2	9.4	–0.23	–0.40	–0.15	1.00	0.99	0.47	0.46
MSCI World	12.5	12.0	9.5	–0.28	–0.31	–0.18	0.99	1.00	0.38	0.38
IFCG-CW	9.9	8.6	16.4	0.81	3.34	0.37	0.47	0.38	1.00	0.85
IFCG-EW	16.8	15.5	15.4	0.44	0.75	0.38	0.46	0.38	0.85	1.00

Total returns: International Finance Corporation Global Indexes in U.S. dollars.

MSCI = Morgan Stanley Capital International, AC = All Country, IFCG = IFC Global Composite, CW = Cap-weighted, EW = equal-weighted.

TIME-VARYING RETURN CHARACTERISTICS

Time Variation in Skewness and Kurtosis

Exhibit 3 details the skewness of the emerging market returns over the entire sample. For nine of twenty countries, the data begin in January 1976, but the IFC data base was created in 1980 and backfilled. The first bar of each pair represents the skewness in the 1980s, and the second bar represents the skewness in

Finally, credit ratings are often associated with both types of integration.

Cross-Sectional Patterns in Skewness and Kurtosis

The rank-order correlations of the country attributes with skewness and kurtosis are reported in the second section of Exhibit 8. Exhibits 9 and 10 graph the cross-sectional relation between selected attributes and realized skewness and kurtosis, as well as report R^2s.

Skewness is negatively related to most of the ICRG ratings. These results, however, are particularly sensitive to one observation: Argentina. When Argentina is excluded, the relation between the ratings and skewness is weaker. Lower market capitalization greatly increases the chance of positive skewness in the returns. A negative correlation is also found between the skewness and GDP growth. Skewness is strongly

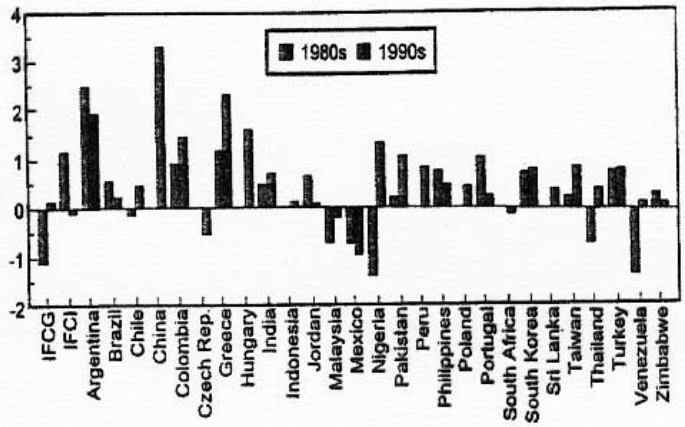
EXHIBIT 8
SKEWNESS, KURTOSIS, AND COUNTRY ATTRIBUTES

Attributes	SKEW	KURT	IICCR	EMCRR	ICRGC	ICRGP	ICRGF	ICRGE	MKTCAP	INFLATE	RGDP	VOL	BETA	EP	BP	DY
Argentina	3.3	20.2	24.8	29.0	43.0	59.0	11.0	15.5	1,214	211	0.3	92	0.52	12.5	3.57	1.0
Brazil	0.2	1.1	35.5	35.0	54.0	64.0	22.0	21.5	6,555	127	3.7	58	−0.26	26.1	2.86	7.2
Chile	0.3	−0.1	26.0	21.0	51.0	47.0	28.0	27.0	2,219	25	3.4	33	0.41	23.9	1.45	6.1
Colombia	1.6	4.1	39.8	42.0	59.5	58.0	29.0	32.0	677	23	4.1	23	0.24	18.1	1.22	6.7
Greece	1.8	6.3	46.9	60.0	59.0	60.0	27.0	30.5	824	18	1.9	30	0.45	11.4	0.88	3.0
India	0.7	1.1	50.6	69.0	56.5	50.0	29.0	33.5	5,373	8	4.5	24	0.01	9.8	0.53	3.6
Jordan	0.2	1.5	37.3	53.0	53.0	44.0	25.0	36.5	1,240	6	6.9	17	−0.07	8.3	0.72	2.7
Malaysia	−0.9	2.8	57.0	65.0	63.0	63.0	26.0	37.0	11,969	4	5.5	29	−0.08	2.4	0.48	2.8
Mexico	−1.0	5.4	28.7	31.0	54.0	62.0	22.0	24.0	5,611	55	3.7	47	0.29	6.2	0.75	2.0
Nigeria	1.5	19.6	22.0	27.0	42.0	42.0	15.0	26.5	576	15	−0.6	46	1.75	22.4	0.42	1.9
Pakistan	1.2	4.3	30.4	50.0	48.5	41.0	23.0	33.0	643	7	6.5	12	−0.04	13.8	0.80	5.8
Philippines	0.7	3.7	22.1	25.0	47.0	44.0	20.0	29.5	1,495	15	1.8	34	0.13			7.6
Portugal	2.4	12.9	54.3	71.0	72.5	70.0	37.0	37.5	1,591	20	2.8	40	1.13	6.9	0.31	1.7
South Korea	0.6	0.4	59.9	73.0	65.5	60.0	34.0	37.0	6,490	10	7.7	29	0.48	7.1	0.55	0.2
Taiwan	0.6	1.4	74.5	68.0	81.0	77.0	44.0	40.5	7,267	5	8.6	22	0.10	7.0	0.39	1.3
Thailand	−0.2	1.8	53.6	62.0	60.5	55.0	29.0	36.5	2,004	7	6.4	18	0.05	8.2	0.78	5.0
Turkey	1.0	1.0	39.7	54.0	53.0	55.0	26.0	25.0	487	48	4.1					
Venezuela	0.2	2.2	36.9	31.0	56.5	63.0	21.0	28.5	1,298	14	0.7	47	−0.03	7.6	0.38	0.8
Zimbabwe	0.0	1.2	22.8	34.0	47.0	44.0	23.0	27.0	200	13	3.0	42	0.61	29.2	0.75	11.2
Rank Correlations: All Countries																
Skewness	1.00	0.69	−0.11	0.00	−0.11	0.04	−0.14	−0.24	−0.51	0.44	−0.41	0.38	0.47	0.11	0.39	−0.20
Kurtosis	0.69	1.00	−0.31	−0.24	−0.31	−0.01	−0.47	−0.39	−0.30	0.47	−0.63	0.61	0.72	0.04	0.29	−0.37
Rank Correlations: Ex-Argentina																
Skewness	1.00	0.52	0.05	0.19	0.11	−0.01	0.20	0.13	−0.54	−0.12	−0.27	−0.12	0.51	0.15	−0.10	−0.07
Kurtosis	0.52	1.00	−0.21	−0.12	−0.15	−0.08	−0.25	−0.07	−0.27	−0.09	−0.56	0.28	0.84	0.07	−0.30	−0.28

Legend:

SKEW	Skewness IFCG U.S.$ country returns (1987:04-1997:03).
KURT	Kurtosis IFCG U.S.$ country returns (1987:04-1997:03).
IICCR	*Institutional Investor* country credit rating (1987:03).
EMCRR	*Euromoney* country risk rating (1986:09).
ICRGC	Political Risk Services: International Country Risk Guide — Composite (1987:03).
ICRGP	Political Risk Services: International Country Risk Guide — Political (1987:03).
ICRGF	Political Risk Services: International Country Risk Guide — Financial (1987:03).
ICRGE	Political Risk Services: International Country Risk Guide — Economic (1987:03).
MKTCAP	IFC Global Market Capitalization (millions of U.S.$, 1987:03).
INFLATE	Trailing annual CPI inflation, IMF (1978-1987) in percent.
RGDP	Trailing annual real GDP growth, IMF (1978-1987) in percent.
VOL	Annualized volatility, monthly IFCG U.S.$ returns (1981:01-1987:03) in percent.
BETA	Beta versus MSCI World, monthly IFCG U.S.$ returns (1981:01-1987:03).
EP	IFC Global earnings/price ratio (1987:03).
BP	IFC Global book/price ratio (1987:03).
DY	IFC Global dividend yield (1987:03) in percent.

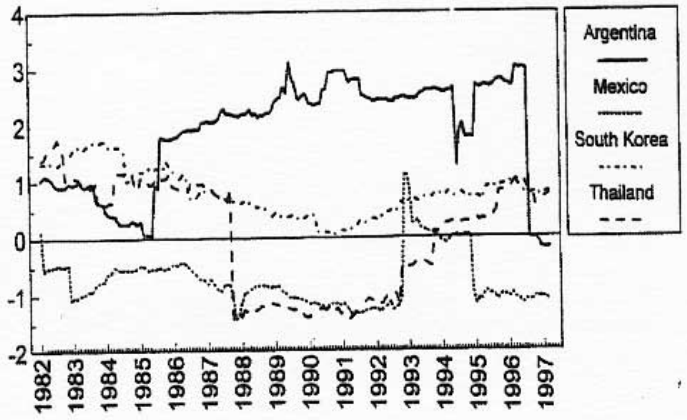
EXHIBIT 3
SKEWNESS IN THE 1980s AND 1990s



Monthly U.S. $ total returns through March 1997.

Source: International Finance Corp. Global Indexes.

EXHIBIT 5
SKEWNESS THROUGH TIME —
SELECTED COUNTRIES



Five-year trailing skewness. Monthly U.S. $ total returns.

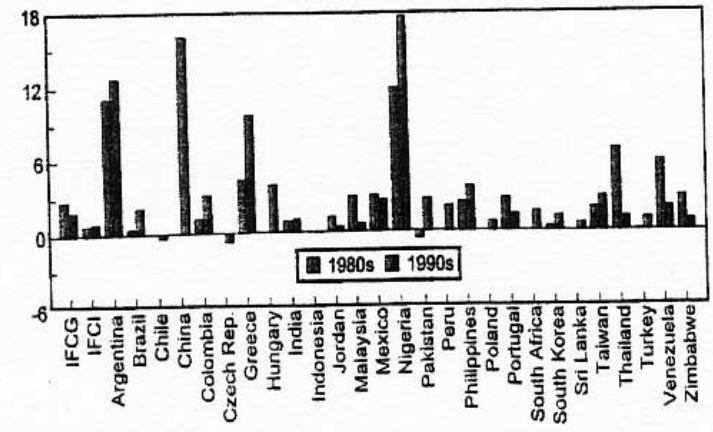
Source: International Finance Corp. Global Indexes.

the 1990s. We split the sample between the 1980s and 1990s because Bekaert [1995] details that many of the capital market liberalizations occur in the early 1990s. Remarkably, more countries have positive skewness in the 1990s than in the 1980s.

Exhibit 4 replicates this analysis for excess kurtosis. All but a single country has excess kurtosis in the 1990s. For many of the countries, the degree of kurtosis has been reduced in the 1990s compared to the 1980s.

Exhibits 5 and 6 explore the time series patterns in the skewness and kurtosis. We consider a subsample of four countries: Argentina, Mexico, South Korea, and Thailand, and graph rolling five-year skewness and kurtosis. As with the analysis in Exhibit 2, we need to be careful because it is difficult to estimate these higher moments with only sixty observations.[8]

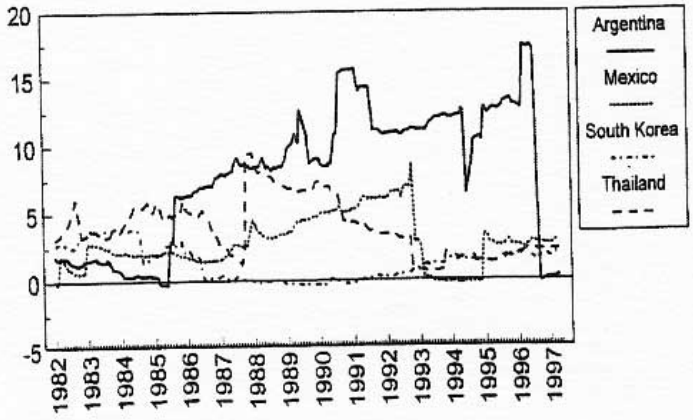
EXHIBIT 4
EXCESS KURTOSIS IN THE 1980s AND 1990s



Monthly U.S. $ total returns through March 1997.

Source: International Finance Corp. Global Indexes.

EXHIBIT 6
EXCESS KURTOSIS THROUGH TIME —
SELECTED COUNTRIES



Five-year trailing kurtosis. Monthly U.S. $ total returns.

Source: International Finance Corp. Global Indexes.

EXHIBIT 7
BEHAVIOR OF EMERGING MARKET RETURNS IN THE 1980s AND 1990s

Country	Observations in 1980s	Observations in 1990s	Tests Whether Differences Exist in Decades: Mean	Variance	Skewness	Kurtosis	Joint
Argentina	120	87	0.8528	0.0413	0.6482	0.7866	0.1697
Brazil	120	87	0.9103	0.5574	0.5371	0.1453	0.5342
Chile	120	87	0.3403	0.0103	0.0486	0.4933	0.0222
Colombia	60	87	0.6581	0.0096	0.1882	0.1743	0.0000
Greece	120	87	0.4471	0.6682	0.0867	0.1178	0.3474
India	120	87	0.7246	0.0068	0.5652	0.8832	0.0449
Jordan	120	87	0.7883	0.1060	0.1693	0.2935	0.0378
Malaysia	60	87	0.9673	0.3758	0.4532	0.1745	0.6163
Mexico	120	87	0.8663	0.0096	0.7083	0.7376	0.0005
Nigeria	60	87	0.1026	0.2774	0.2487	0.4344	0.0496
Pakistan	60	87	0.7684	0.0001	0.0297	0.0015	0.0000
Philippines	60	87	0.0061	0.2946	0.7422	0.4022	0.0857
Portugal	47	87	0.0343	0.0027	0.2167	0.4705	0.0296
South Korea	120	87	0.0290	0.4046	0.8529	0.3924	0.2972
Taiwan	60	87	0.0350	0.3504	0.3535	0.5411	0.0321
Thailand	120	87	0.2505	0.0385	0.2846	0.0658	0.0023
Turkey	36	87	0.1105	0.0508	0.8598	0.2307	0.3509
Venezuela	60	87	0.2141	0.1896	0.0924	0.1025	0.1031
Zimbabwe	120	87	0.8459	0.4411	0.7669	0.2187	0.4154
IFCG	60	87	0.0624	0.2252	0.0687	0.6577	0.0134
MSCI AC World	24	87	0.2005	0.5971	0.2737	0.7564	0.3676
MSCI World	120	87	0.0974	0.4099	0.3770	0.2115	0.2103

Probability values are reported. Values of 0.500 indicate significant differences at the 5% level of significance.

EXPLAINING THE DEVIATIONS FROM NORMALITY

Fundamental Characteristics of Emerging Market Returns

Our first task has been to detail that emerging market returns deviate from the standard distributional assumptions and that the distributional characteristics change over time. The next task is to try to explain what forces determine the cross-sectional differences in distributional characteristics.

Exhibit 8 details a number of fundamental characteristics of emerging countries. Our method is to examine country characteristics in March 1987 and explore whether they are correlated with realized skewness and kurtosis over the April 1987–March 1997 period. These characteristics include country risk ratings explored in Harlow [1993], Erb, Harvey, and Viskanta [1996], and Diamonte, Liew, and Stevens [1996].

We also consider a number of macroeconomic characteristics such as inflation and trade-to-GDP. The development of the stock market is proxied by the market capitalization-to-GDP ratio. We examine but do not report one demographic variable, average age growth, which is explored in Erb, Harvey, and Viskanta [1997].

Finally, there are a number of financial variables. We consider the market capitalization, the volatility, and the beta versus the MSCI world index. We also report three fundamental ratios: earnings-to-price, book value-to-price, and dividend yield.

Note that a number of these variables are correlated with the market integration process. In particular, market capitalization-to-GDP as well as the world market beta are linked to capital market integration. Trade-to-GDP is often linked to economic integration.

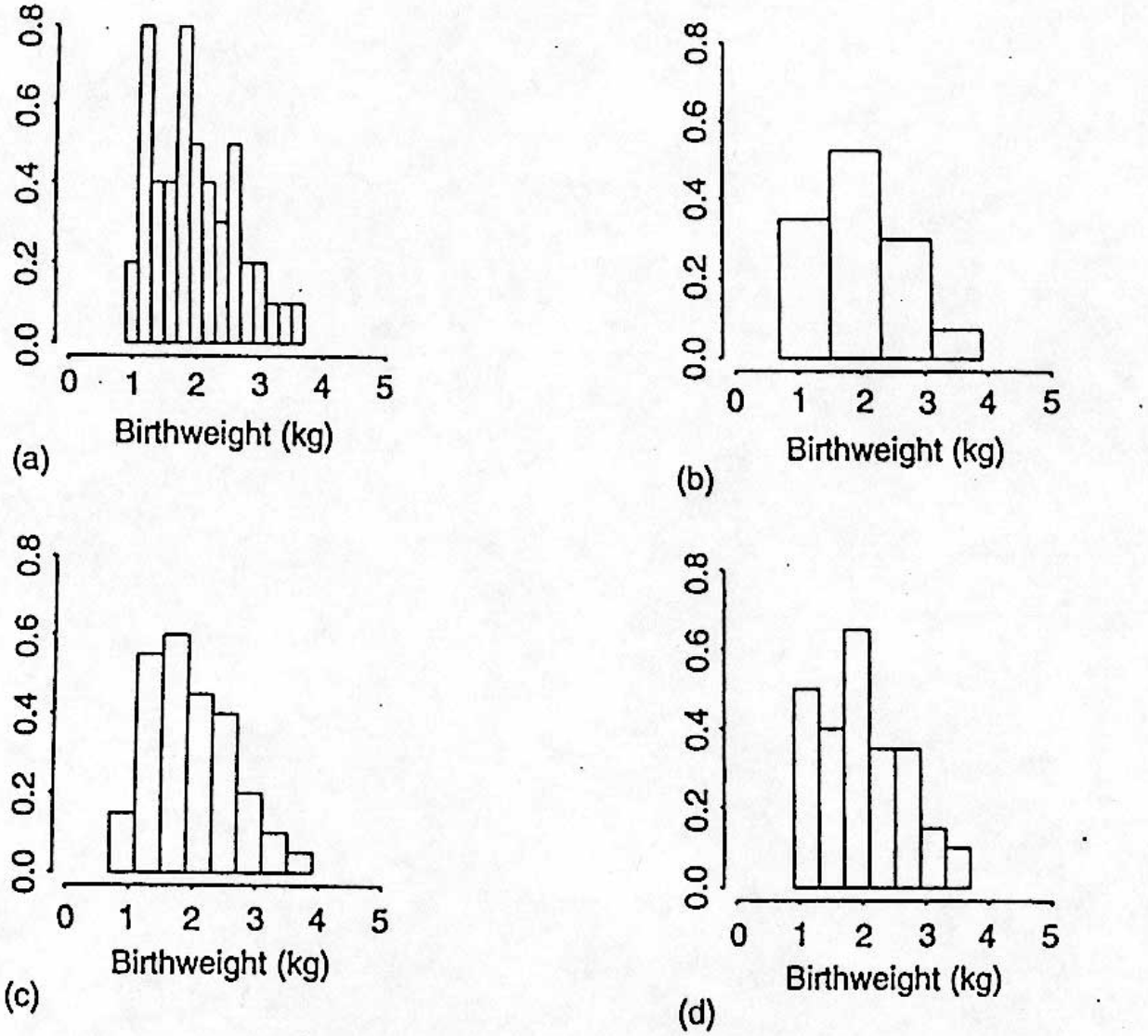


Figure 1.3. *Histograms of birthweight data. Figures (a) and (b) are based on binwidths of 0.2 and 0.8 respectively. Figures (c) and (d) are each based on a binwidth of 0.4 but with left bin edge at 0.7 and 0.9 respectively.*

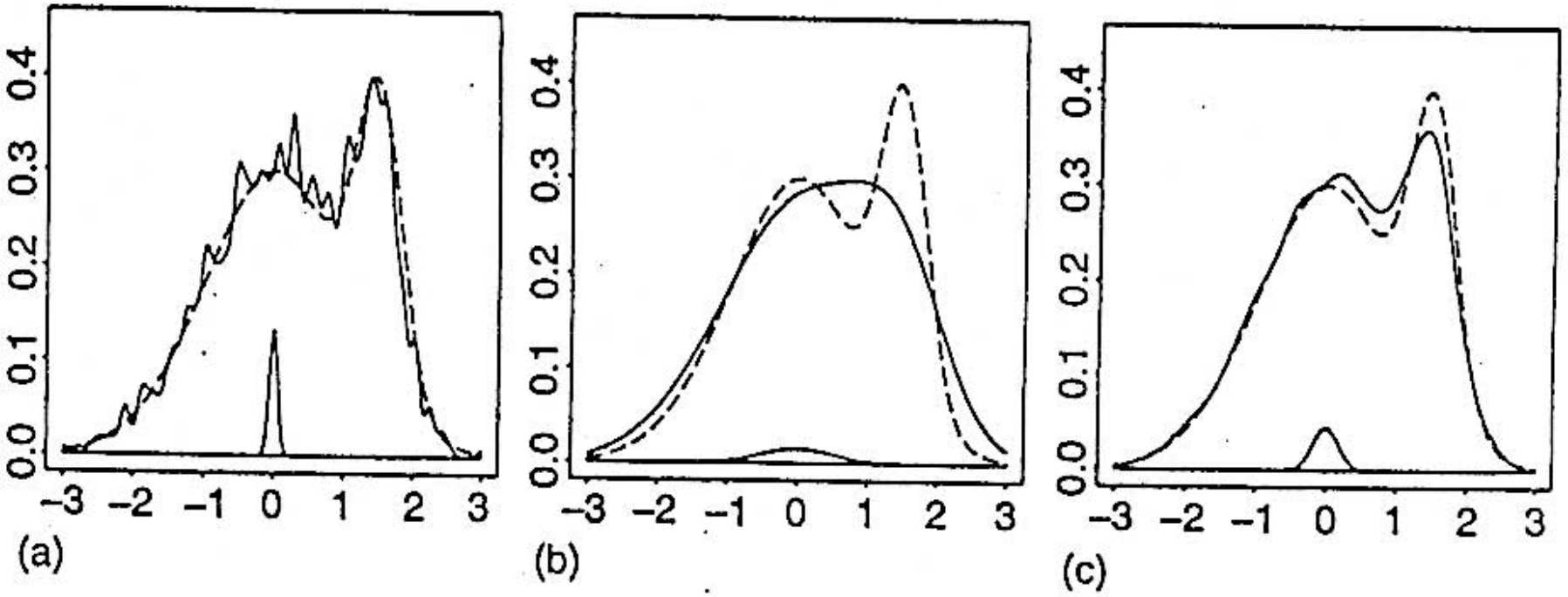


Figure 2.3. *Kernel density estimates based on a sample of* $n = 1000$ *observations from the normal mixture distribution* f_1 *described in the text. The solid line is the estimate, the broken line is the true density. The bandwidths are (a)* $h = 0.06$, *(b)* $h = 0.54$ *and (c)* $h = 0.18$. *The kernel weight for each estimate is illustrated by small kernels at the base of each figure.*

Table 4.5.2 *Some kernels and their efficiencies*

Kernel	$K(u)$	$D(K_{\text{opt}}, K)$
Epanechnikov	$(3/4)(-u^2+1)\ I(\lvert u\rvert \le 1)$	1
Quartic	$(15/16)(1-u^2)^2\ I(\lvert u\rvert \le 1)$	1.005
Triangular	$(1-\lvert u\rvert)\ I(\lvert u\rvert \le 1)$	1.011
Gauss	$(2\pi)^{-1/2}\exp(-u^2/2)$	1.041
Uniform	$(1/2)\ I(\lvert u\rvert \le 1)$	1.060

Note: The efficiency is computed as $\{V(K_{\text{opt}})B(K_{\text{opt}})/[V(K)B(K)]\}^{-1/2}$ for $k = 0$, $p = 2$.

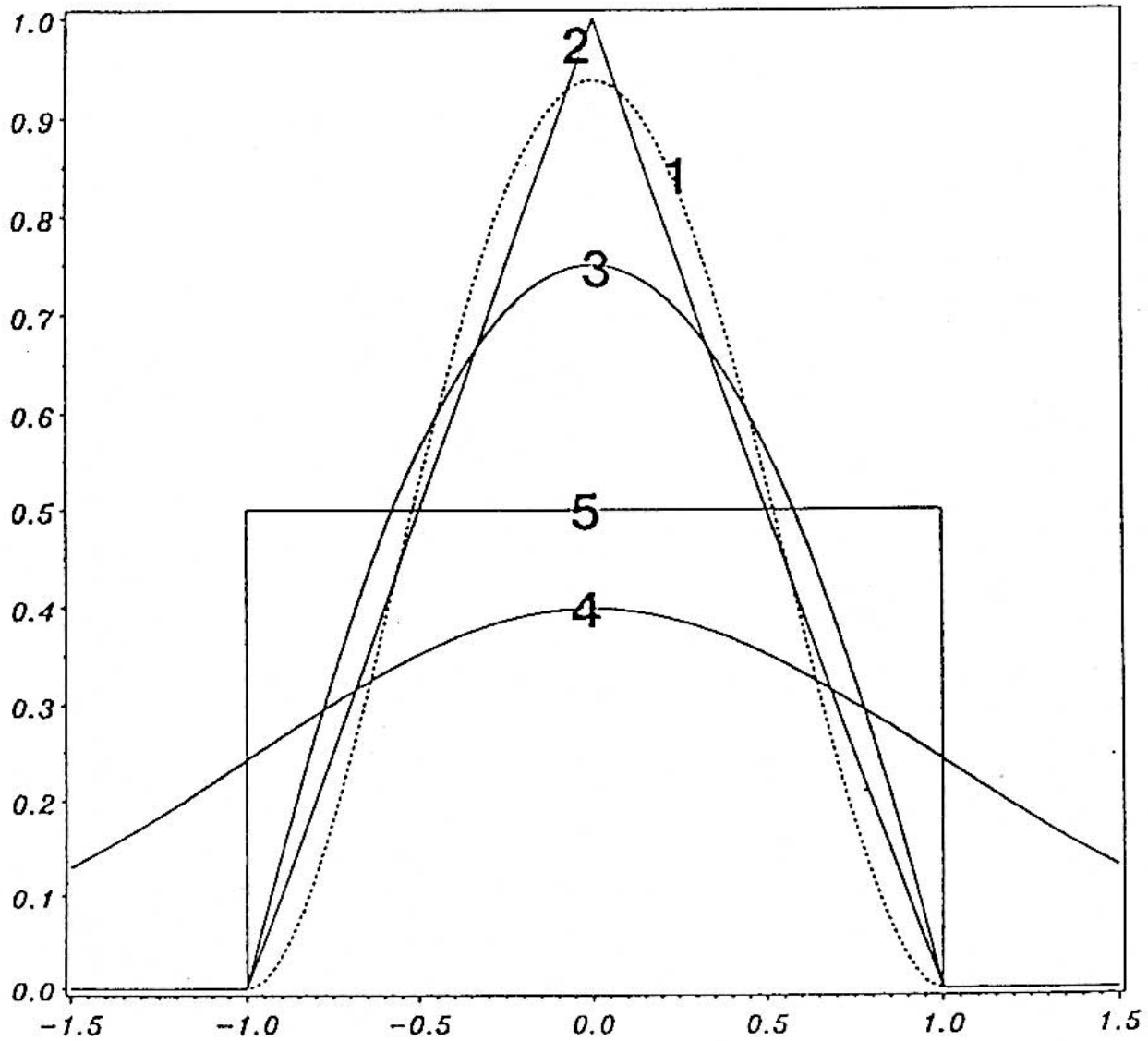
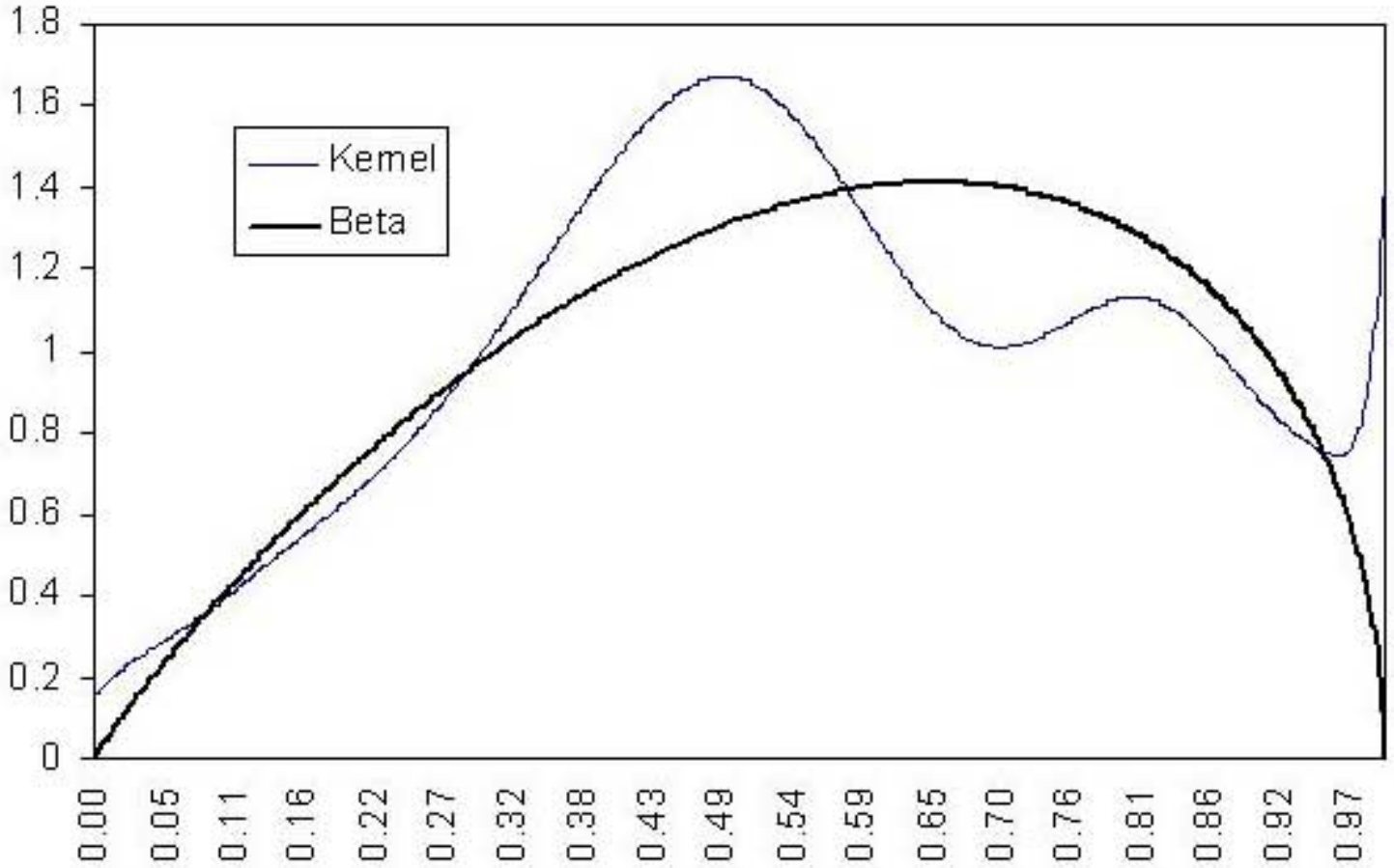
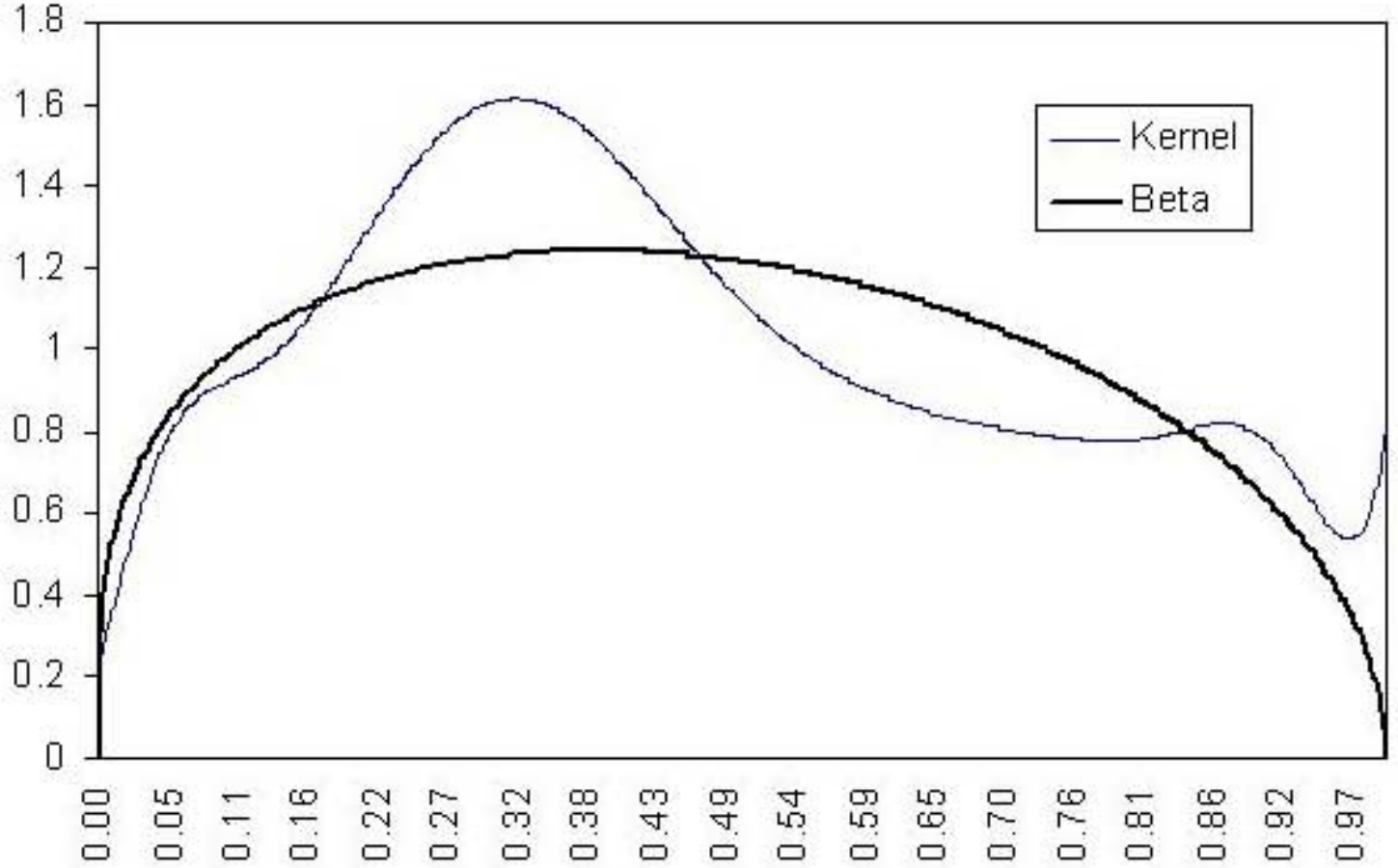


Figure 4.16. Positive kernels for estimating m (from Table 4.5.2). Label 1: quartic; label 2: triangular; label 3: Epanechnikov; label 4: Gauss; label 5: uniform.

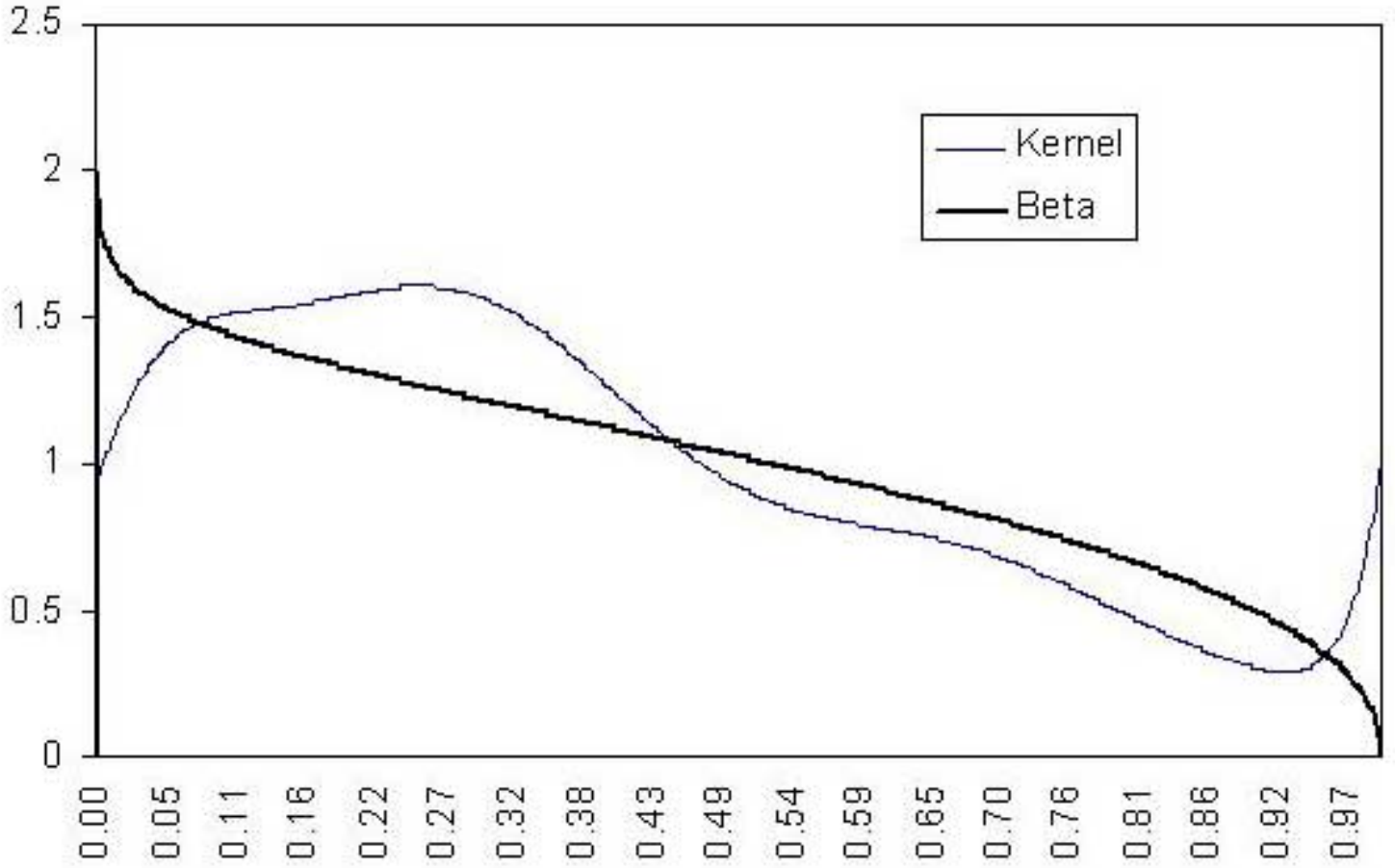
Recovery on senior secured bond



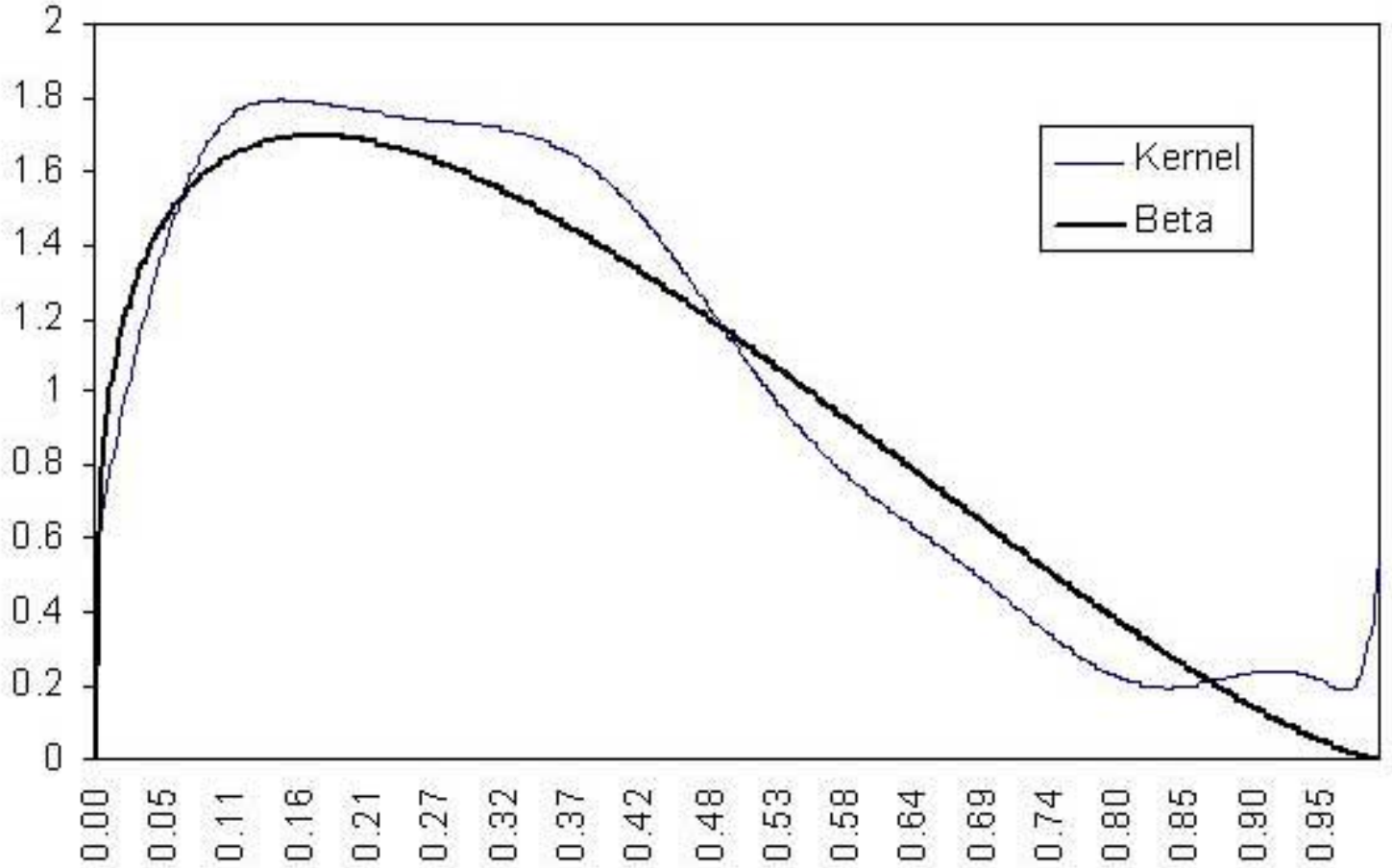
Recovery on senior unsecured bond



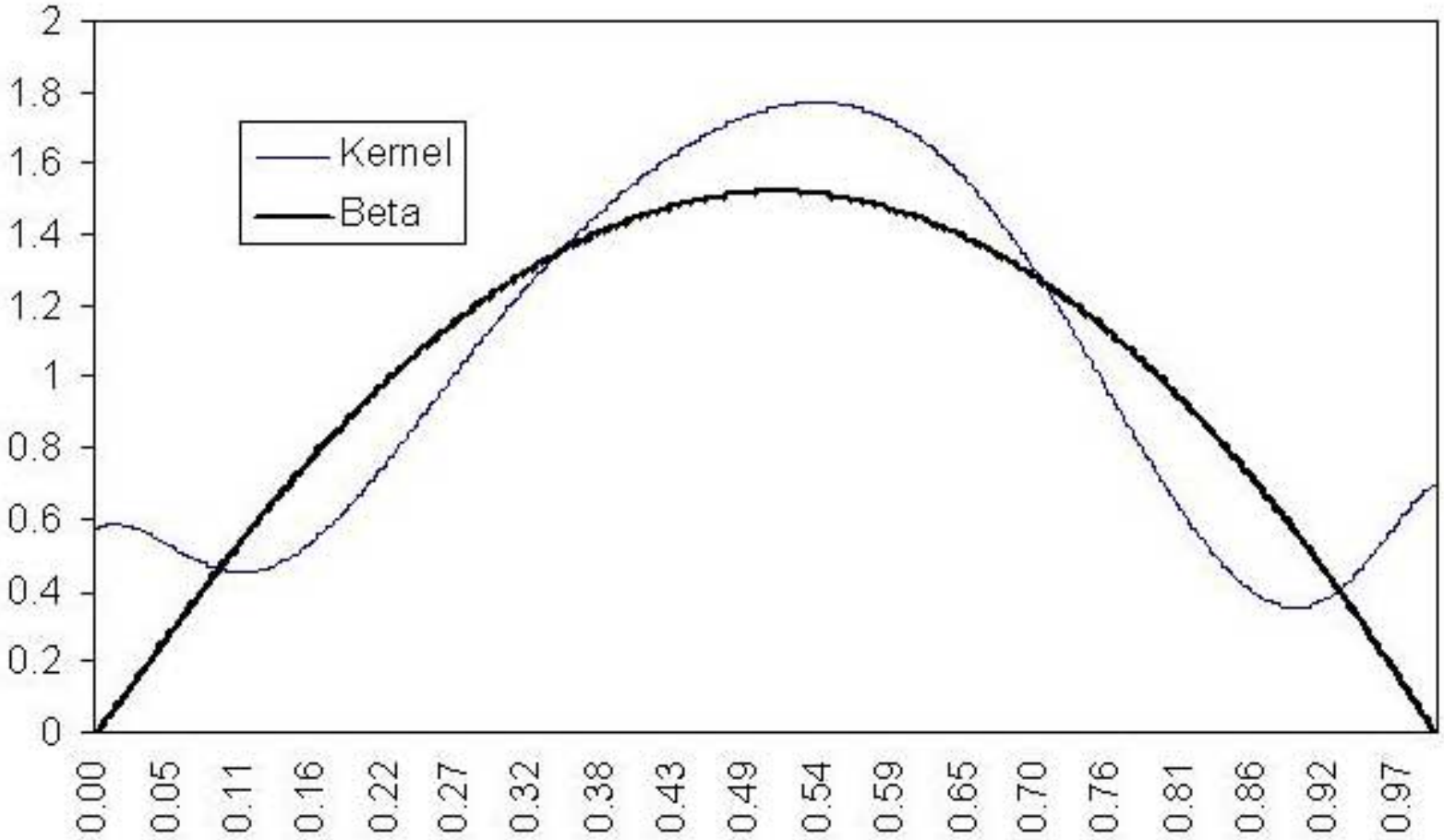
Recovery on junior bond



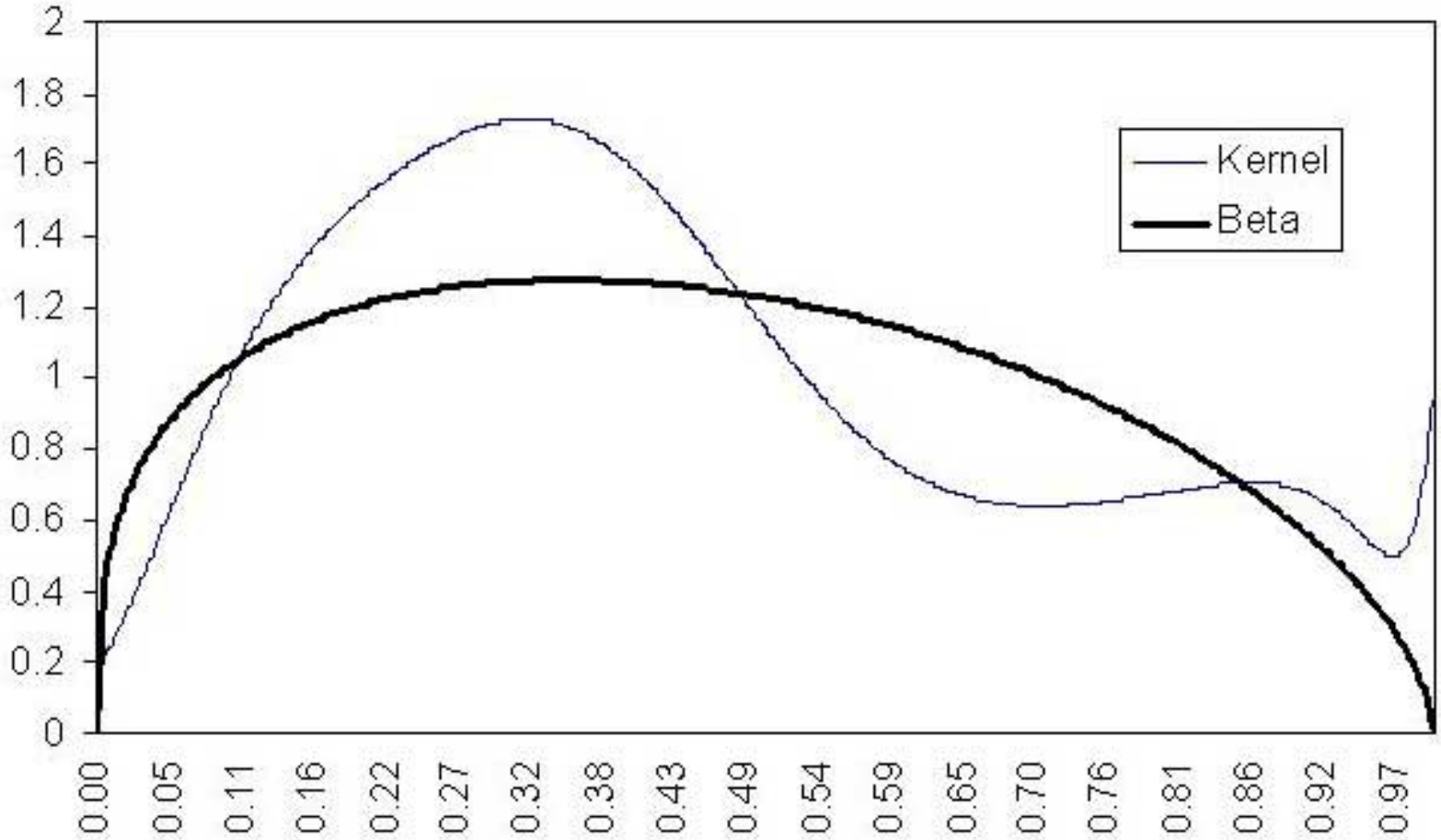
Recovery on junior subordinated bond



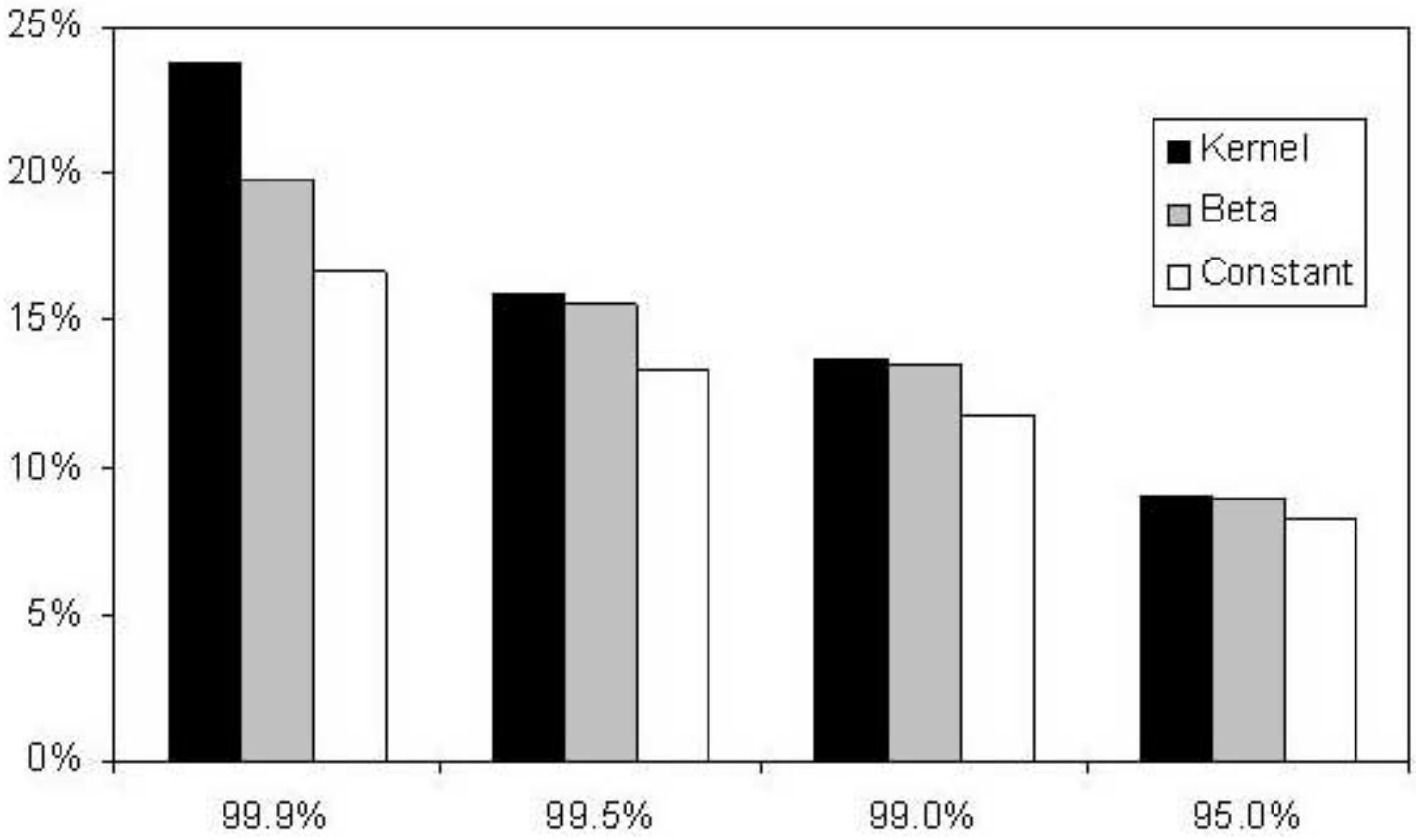
Recovery in high tech sector



Recovery in energy sector



Impact on VaR



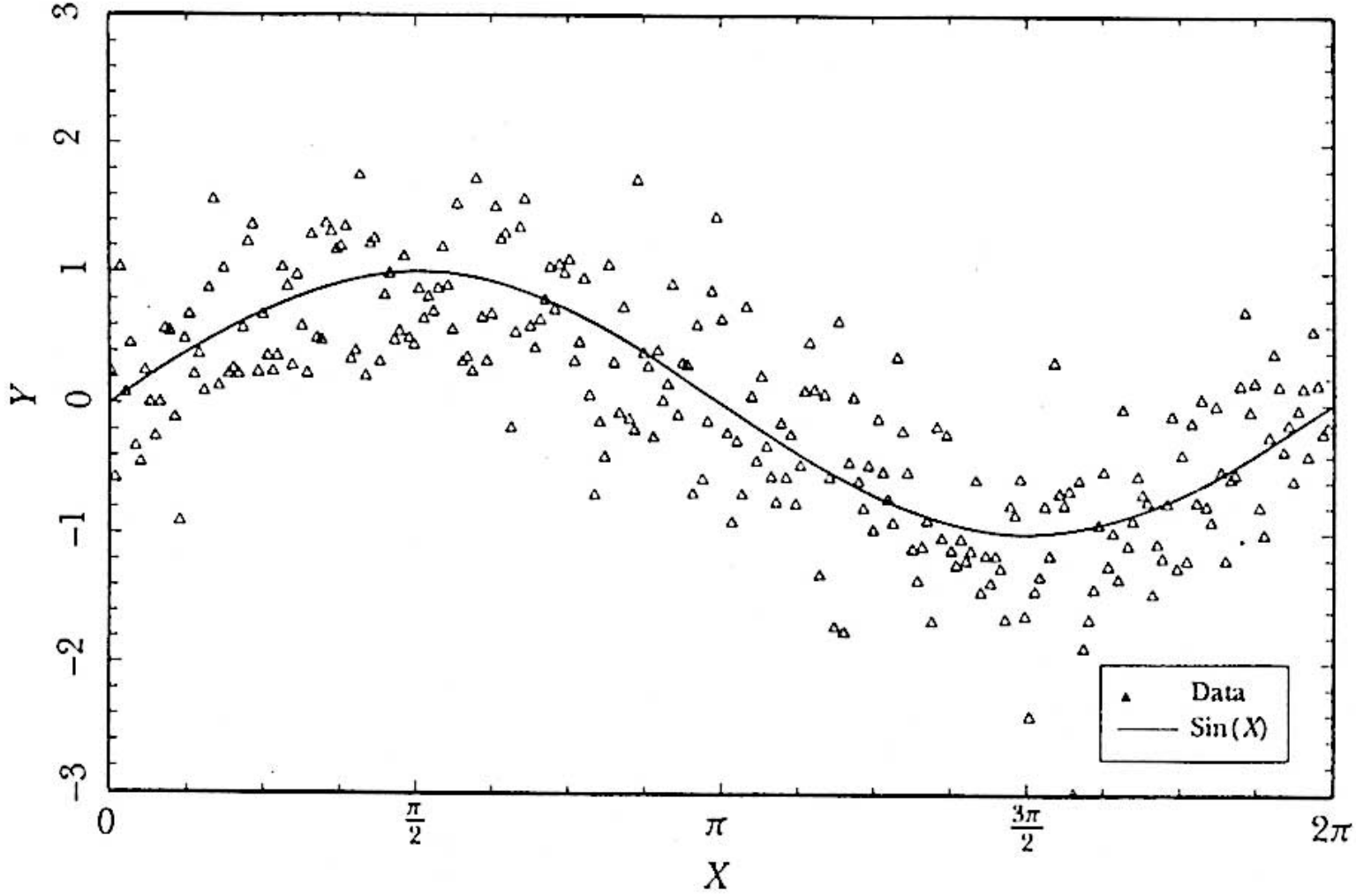
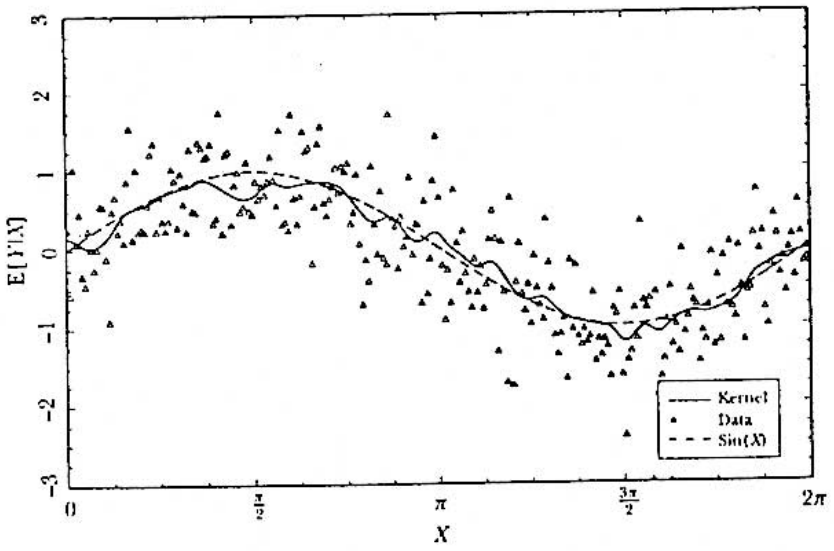
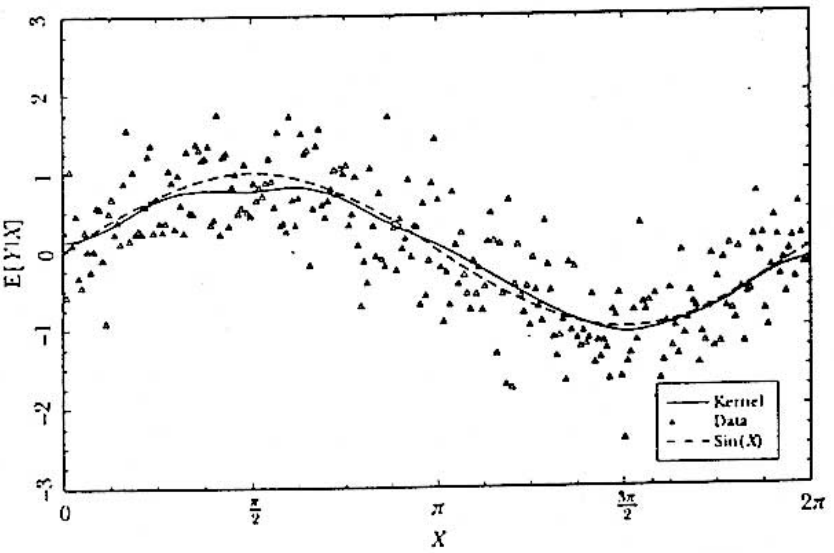


Figure 12.4. *Simulation of* $Y_t = \text{Sin}(X_t) + 0.5\epsilon_t$

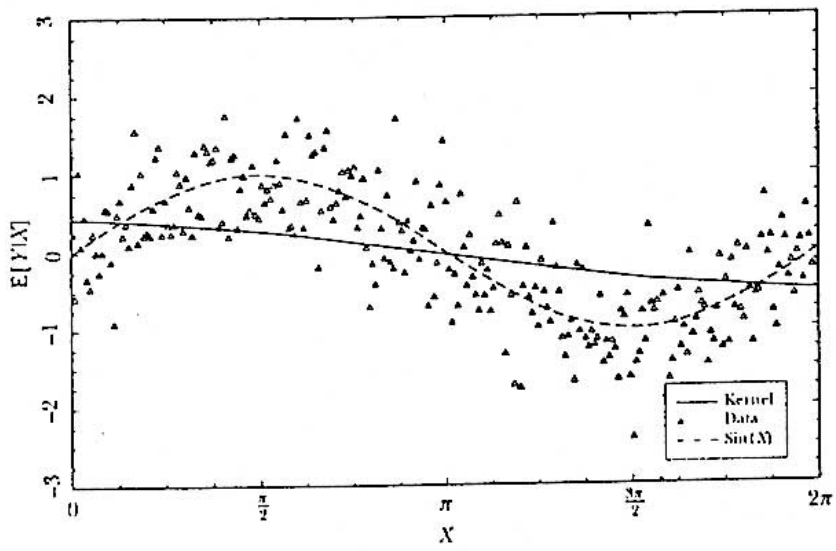
$Y_t = a + b X_t + \varepsilon_t$



(a) $h = 0.1\hat{\sigma}_x$

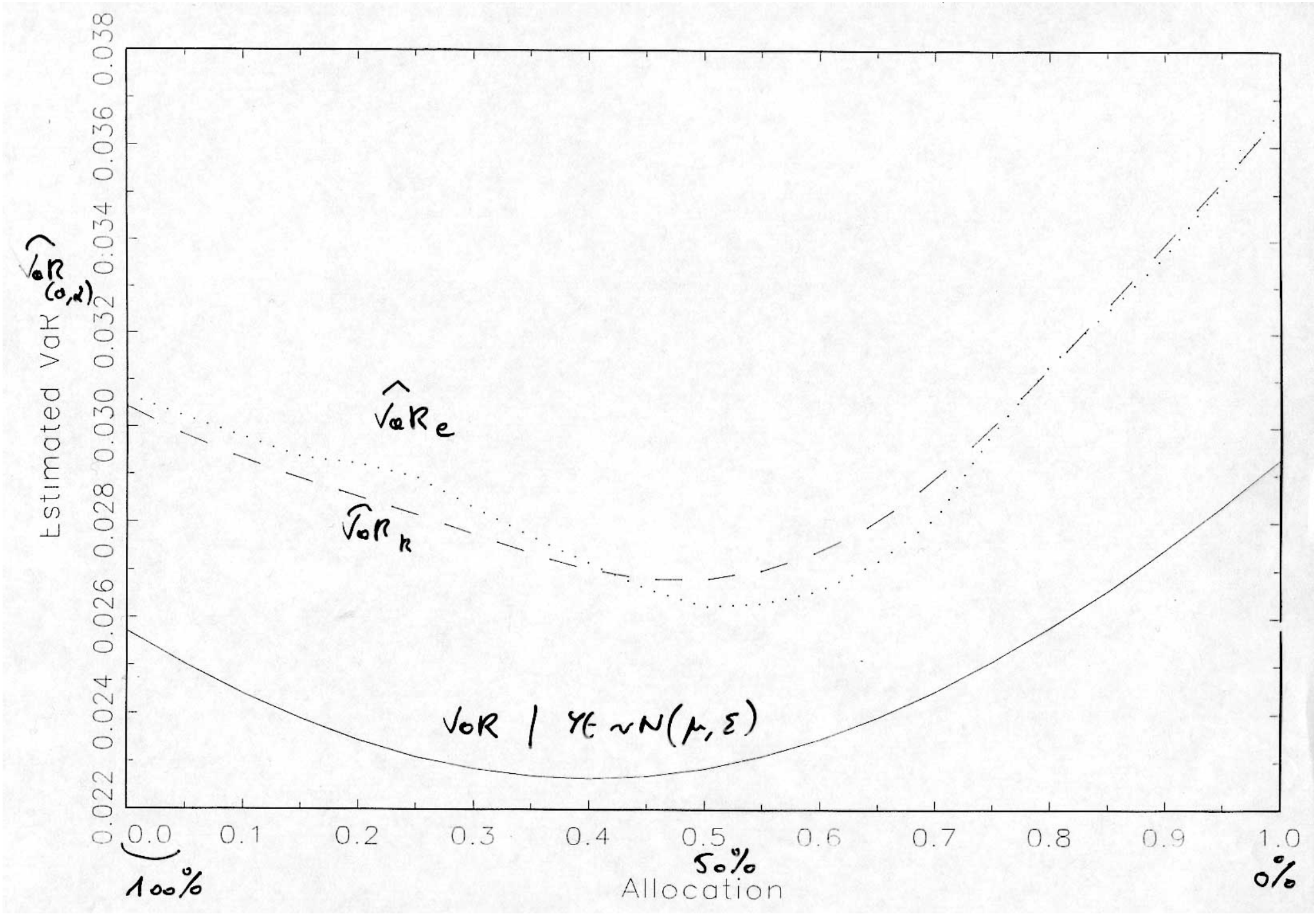


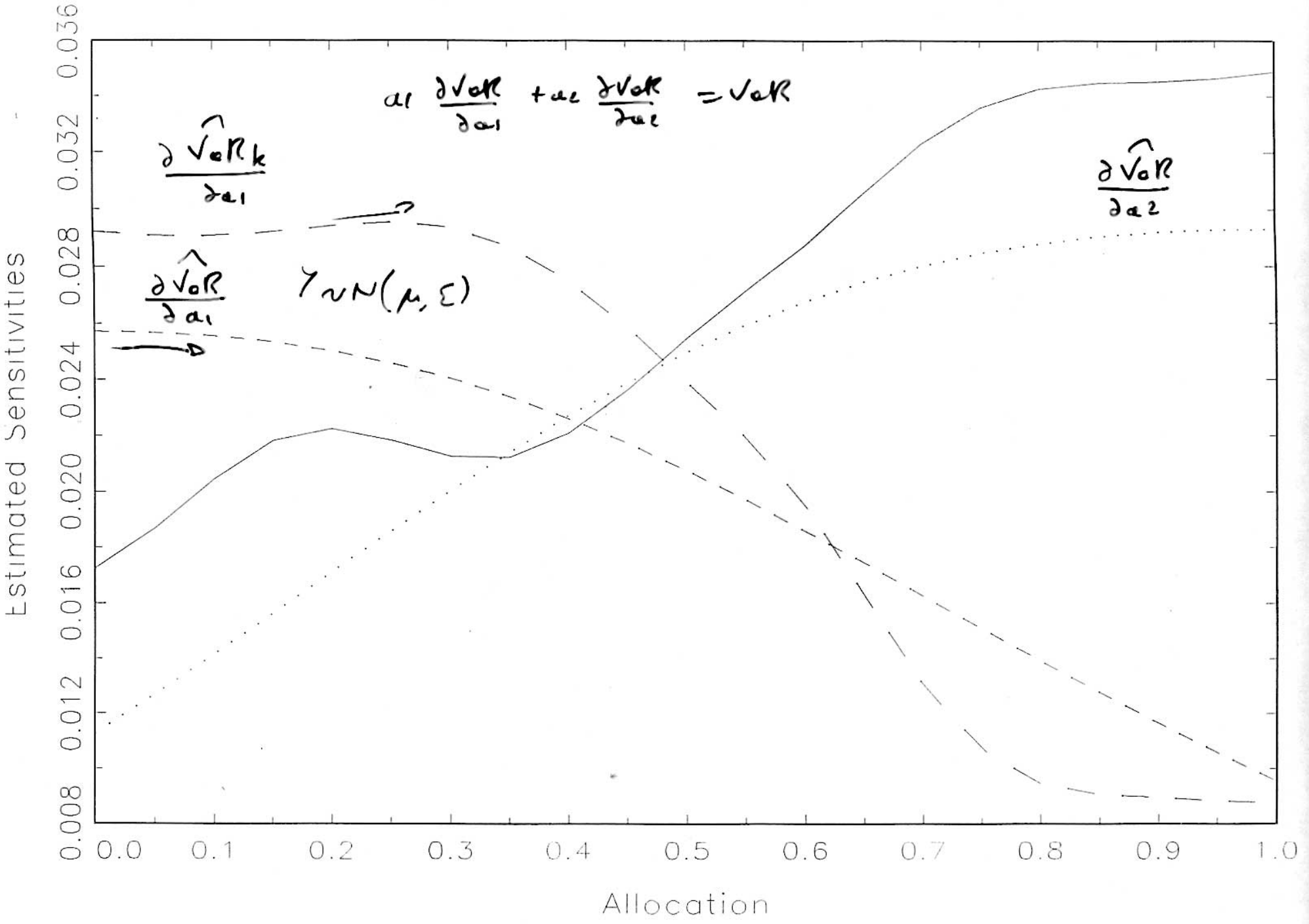
(b) $h = 0.3\hat{\sigma}_x$



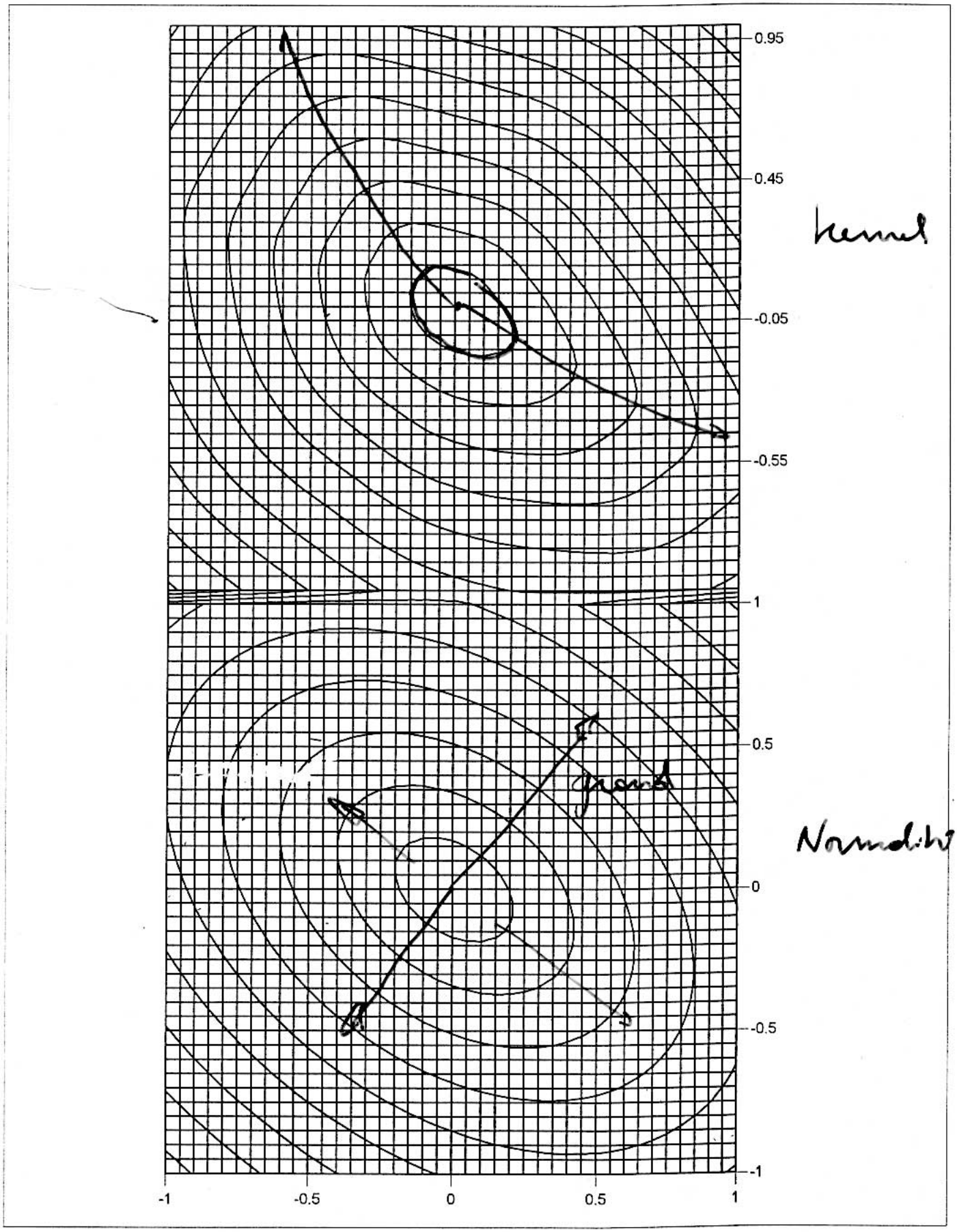
(c) $h = 0.5\hat{\sigma}_x$

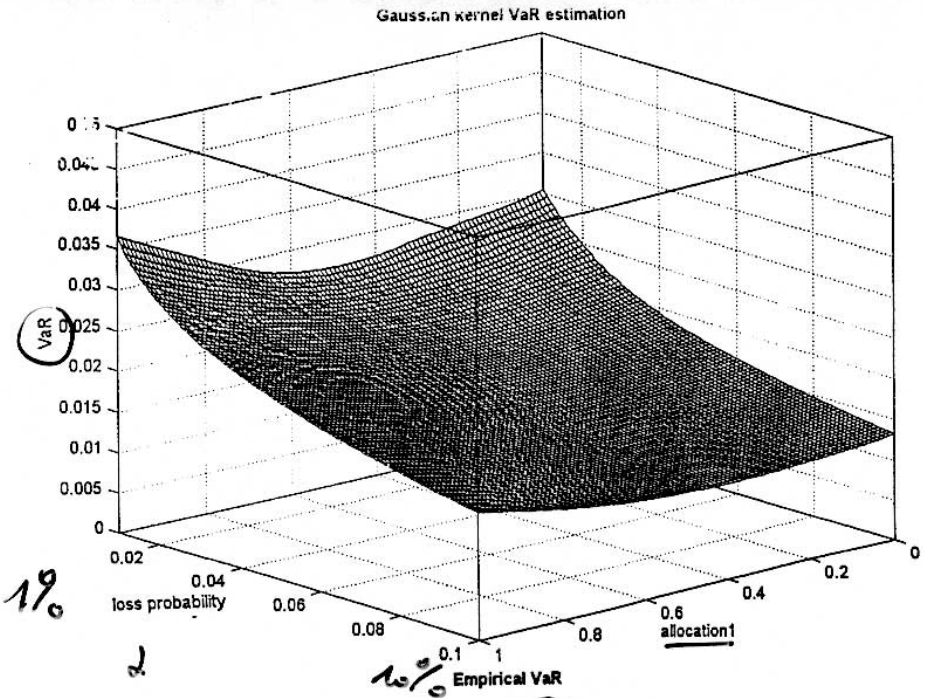
Figure 12.5. Kernel Estimator


Estimated VaR
0.022
0.024
0.026
0.028
0.030
0.032
0.034
0.036
0.038
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Allocation
100%
50%
0%
VaR | Y_t ~ N(μ, Σ)

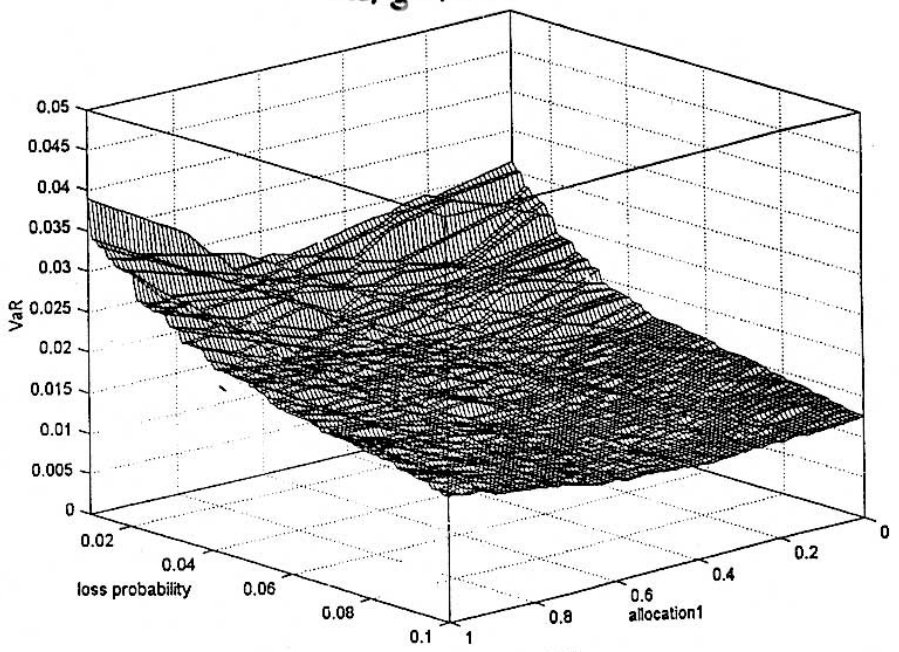

$a_1 \frac{\partial VaR}{\partial a_1} + a_2 \frac{\partial VaR}{\partial a_2} = VaR$
$\frac{\partial \widehat{VaR}_k}{\partial a_1}$
$\frac{\partial \widehat{VaR}}{\partial a_1}$
$Y \sim N(\mu, \Sigma)$
$\frac{\partial \widehat{VaR}}{\partial a_2}$
Estimated Sensitivities
0.008
0.012
0.016
0.020
0.024
0.028
0.032
0.036
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Allocation

ISOVOR 2

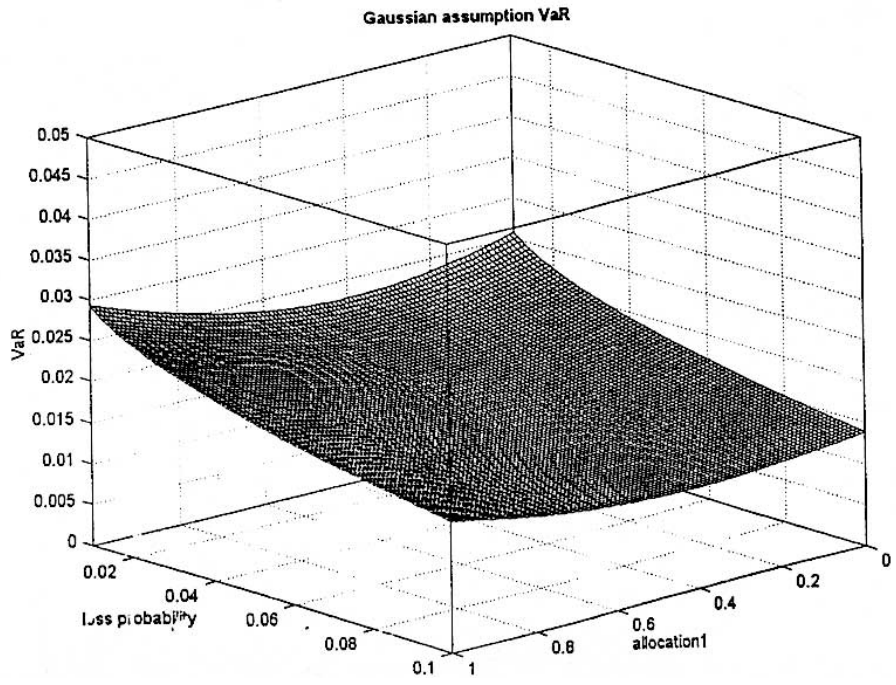




noyau

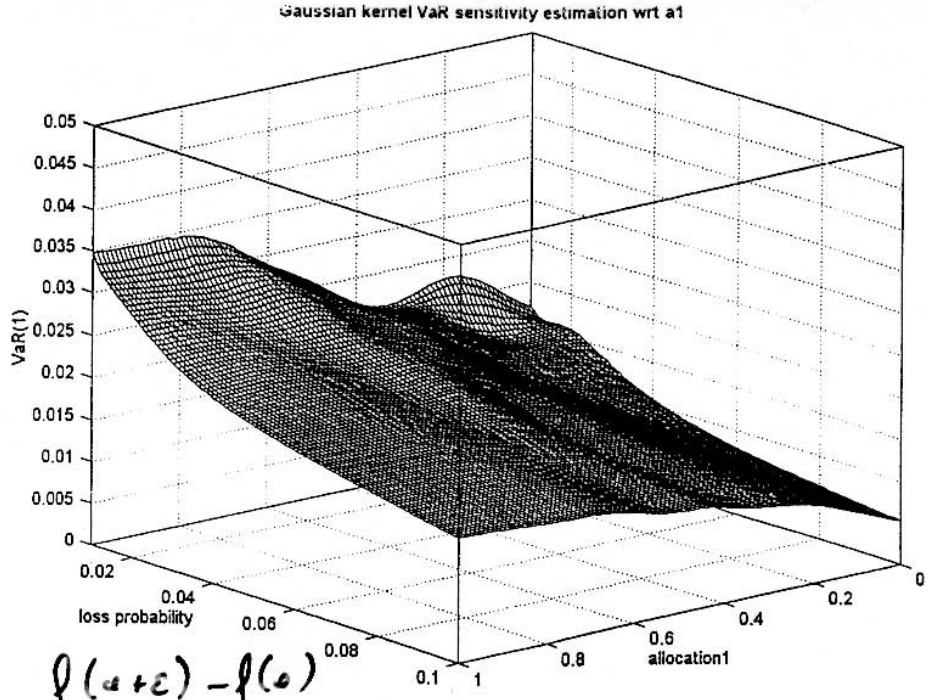


quantile empirique



Normale

$$\frac{\partial VaR}{\partial a_1}$$



$$\frac{\partial f(a)}{\partial a} = \lim_{\varepsilon \to 0} \frac{f(a+\varepsilon) - f(a)}{\varepsilon}$$

$$\frac{f(a + 10^{-14}) - f(a)}{10^{-14}}$$

$$VaR(a_1, a_2, 2)$$

$$\frac{VaR(a_1 + 10^{-14}, a_2, 2) - VaR(a_1, a_2, 2)}{10^{-14}}$$