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CROSS-SECTIONAL DISTRIBUTIONAL PROPERTIES OF FINANCIAL RATIOS IN BELGIAN MANUFACTURING INDUSTRIES: AGGREGATION EFFECTS AND PERSISTENCE OVER TIME

W. BUIJINK AND M. JEGERS*

INTRODUCTION

The purpose of this paper is to add evidence on cross-sectional univariate distributional properties of financial ratios to the previous results of Deakin (1976) and Frecka and Hopwood (1983) amongst others. The ratios studied are eleven of the twelve extensively used in Foster (1978).

The assumption tested in this paper is that ratios, either in the original or in a suitably transformed form, are normally or at least symmetrically distributed. More specifically, the analysis centers on the question whether this assumption is more often true at a lower level of firm aggregation, that is in more homogeneous industries. Additionally, some results are presented on the persistence over time of the form of the ratio distributions.

A large data base with the annual accounts of Belgian limited companies for each of the years from 1977 to 1981 is used. However, attention is restricted to the manufacturing industries.

BACKGROUND

Evidence on the character of financial ratio distributions is important because it guides the choice of statistical tools (Foster, 1978, p. 170 sqq.). In many studies using ratios, statistical methods are employed that rely heavily on, univariate or multivariate, normality assumptions. A case in point is the studies on financial distress prediction which use discriminant analysis. If it can be shown that

* The authors are respectively, from the Faculty of Economics, University of Limburg, The Netherlands; and the Faculty of Applied Economics, R.U.C.A., University of Antwerp, Belgium. The article was written when the first author was Research Assistant at the Faculty of Applied Economics, R.U.C.A., University of Antwerp, and the second author was a Research Assistant with the Belgian National Fund for Scientific Research. They wish to acknowledge the helpful comments of the participants, especially G. Foster, of a workshop at the European Institute for Advanced Studies in Management in Brussels, on an earlier version of this paper. Constructive comments were also made by B. De Brabander and F.J. Thomson. Any remaining errors are the authors' responsibility. (Paper received August 1984, revised October 1985)

ratios are not distributed normally or symmetrically in raw, transformed and/or truncated form, the users of financial ratios will have to turn to non-parametric statistical techniques.

There are a number of reasons why distributions of the raw scores of financial ratios, even within a homogeneous population of firms, cannot be expected to be normal or even symmetrical. The first is that it is in fact a distribution of the quotient of two variables, which have their own distribution that one is looking at, and that even if these component distributions are normal[1] this does not lead to a normal ratio distribution (cf. Barnes, 1982; and Marsaglia, 1965). The second reason is that there will, most of the time, be outside pressure on firm management to keep at least some of the ratios within certain 'acceptable' limits. The third reason is that a number of ratios do not have a range of possible scores of $(-\infty, +\infty)$ but possess a lower bound of zero, which may lead to skewness.

Additionally, lack of homogeneity of the population of firms looked at may constitute a fourth reason. If this is the case mixtures of ratio-distributions of firms from different economic environments are looked at, and there is indeed evidence that there exist sizable inter-industry differences in financial ratios.[2] These differences seem to be due in the first place to differences in the underlying economic conditions affecting the industries. Clear examples of such differences and their effects on ratios are given by Gupta and Huefner (1972).

It is not clear what form of ratio distributions the first reason for non-normality points to. In effect it seems to suggest that it is more appropriate to study the component distributions, because given the distributional form of these and their correlation the form of the ratio distribution can in principle be deduced.[3] The second reason leads to the expectation of shorter and less populated distributional tails in one or both directions. The third reason points to the use of skewness reducing transformations to achieve normality or symmetry, while the fourth reason suggests that the analysis of the form of ratio distributions should take into account the degree of homogeneity of the population of the firms studied.

Table 1 provides a summary of previous research,[4] and although it indicates that evidence in this area is not abundant, some guidance may be gained from it.

First, the work of Bird and McHugh (1977), Frecka and Hopwood (1983) and Beecher, Ezzamel and Mar-Molinero (1984) suggests that the level of aggregation on which the data are analysed does matter.[5] This seems to be true even before transformation. Second, transformation improves goodness-of-fit to the normal distribution. Also apparent is the beneficial effect of truncation (Frecka and Hopwood, 1983).

Persistence of the form of the ratio distribution over time is not discussed in any of the papers listed in Table 1, yet it seems obvious that results are strengthened if stability over time of distributional form can be detected.

DATA, RATIOS AND METHOD

Data

Data were taken from the annual magnetic tapes of the 'Balanscentrale', a department of the National Bank of Belgium, on which the annual accounts of *all* companies established on the basis of Belgian law in the form of a N.V., P.V.B.A., C.V. or B.V.[6] and exceeding certain size limits can be found. The size limits are: 50 employees, or sales exceeding 50 million B.F. (excluding VAT), or total assets minimally worth 25 million B.F. If a company exceeds one of three further size limits, viz. 100 employees, sales of 100 million B.F., or total assets worth 50 million B.F. it has to file more detailed annual accounts.[7]

Thus there are either concise or complete annual accounts depending on a company's size. This has an effect on the computation of the ratios.

Only annual accounts with an accounting fiscal year ending on December 31, are used.[8] A large majority of the companies on the 'Balanscentrale' tape have such a fiscal year (see Table 2).

Ratios

Table 3 shows the eleven financial ratios (Foster, 1978, pp. 28–36) which are examined in this paper.[9] Ratios five to eleven were not calculated for concise annual accounts.

Method

Aggregation Level and Ratio Distributions

To investigate the effect of aggregation level on the acceptance of the normality or symmetry hypothesis, ratio distributions are analysed at two levels of aggregation: the two- and three-digit N.A.C.E. manufacturing industries.[10] On both of these levels the eleven ratio distributions are looked at in each manufacturing industry with ten or more observations. Appendix A gives an idea of the number of industries involved in the analysis at both levels of aggregation. It is shown there that in 1977 some 70 three-digit industries and 18 two-digit industries were looked at. Results are thus obtained for each of the five years 1977–1981.

Normality and Symmetry Tests

(i) Normality: Lilliefors K–S test

The χ^2 test of goodness-of-fit to normality is not appropriate since the samples in this paper are frequently too small. Several alternatives are suggested in the

Table 1

Previous Research on Financial Ratio Distributions

Author(s)	*Country*	*Type of Firm*	*Period*	*Level(s) of Aggregation*	*Number of firms at each level of Aggregation*	*Number of Ratios*	*Transformation (NT – no transformation)*	*Truncation*	*Normality Test*	*Level of Significance*	*% Normal Distributions Raw Data*	*% Normal Distributions after most successful transformation or truncation (if any)*
Deakin (1976)	USA	Manufacturing companies on COMPUSTAT tape	1955–1973	Overall, and 6 S.I.C. industry subgroups (1)	Overall, 454(1955)–1114(1973); industry, minimum 30	11	NT, SQR, log (2)	none	Chi2	5% (3)	15% (overall)	28% (overall)
Bird & McHugh (1977)	Australia	Listed public companies in food, electrical and accommodation industries	1967, 1969, 1971	3 industries, food, electrical, accommodation	Food, 26, electrical, 19 accommodation, 23	5	NT	none	Shapiro, Wilk (4)	5%	67%	not applicable
Bougen & Drury (1980)	UK	Not specified	1975	Overall, several industries subgroups	Overall, 700 + industry, minimum 30	7	NT, SQR, log (5)	yes (6)	Chi2	5%	not given (overall)	0% (overall) (7)
Donnithorne (1981)	Canada	Manufacturing companies on COMPUSTAT tape	1960–1978	Overall	62(1960)–152(1978)	11	NT	yes (6)	K.S. (8)	5%	not given (overall)	0% (overall) (9)

Ooghe & Verbaere (1982)	Belgium	Limited companies from various industries on BALANSCENTRALE tape	1977–1978	Overall	753	146	NT	none	Lilliefors K.S. (10)	1%	0%	not applicable
Frecka & Hopwood (1983)	USA	Manufacturing companies on COMPUSTAT tape	1950–1979	Overall, 3 S.I.C. industries subgroups in 1978–1979	Overall, 346 (1950) – 1243 (1978); industry, minimum 100	11	NT, SQR	yes (6)	Chi2	1%	13% (overall) 38% (industry)	47% (overall) 92% (industry)
Beecher, Ezzamel & Mar-Molinero (1984)	UK	Quoted and unquoted companies on EXSTAT tape	1980–1981	3 industries, textiles, retail food, metals	Textiles, 40 retail food, 26, metals, 25	5	NT, SQR, log	none	Chi2, K.S., Shapiro Wilk	5%	73% (11)	92% (11)

(1) Relevant period for industry subgroups not given.
(2) SQR and log transformation for five ratios only.
(3) If possible the results at five percent are reproduced here for all seven papers.
(4) Shapiro, Wilk (1965).
(5) SQR and log for selected industry subgroups only.
(6) Truncation procedure described in text below.
(7) Results for industries not presented in detail.
(8) K.S. = Kolmogorov-Smirnov test; also uses a t-test without explanation.
(9) Also gives results for all years pooled together.
(10) Lilliefors's version of Kolmogorov-Smirnov test, Lilliefors (1967).
(11) Results for K.S.-test.

Table 2

Percentage of Companies on 'Balanscentrale' Tape with an Accounting Fiscal Year Ending in December

1977	1978	1979	1980	1981
100.0%	86.0%	86.1%	85.6%	85.7%

literature. The most powerful seems to be the Shapiro-Wilk (1965) test but tables are not available for $n > 50$ (Royston, 1982). The second best, the Kolmogorov-Smirnov test, is not appropriate when the mean and the variance of the population distribution are unknown (Gibbons, 1971, p. 86). Lilliefors (1967), using Monte Carlo techniques, constructed a Kolmogorov-Smirnov like test to cope with this problem. To perform this test the mean and the variance of the theoretical normal distribution are estimated from the sample and the maximum difference between the sample cumulative distribution and the hypothesized cumulative normal distribution is determined and compared with the critical value given by Lilliefors.[11]

(ii) Symmetry: two sided sign test

The sign test is a simple exact test based on the binomial distribution. The null hypothesis states that the mean of the empirical distribution equals its median.

Table 3

Financial Ratios Used

- Liquidity
  1. Current ratio (CR)
  2. Quick ratio (QR)
- Leverage
  3. Debt to equity (DE)
  4. Longterm debt to equity (LTDE)
  5. Times interest earned (TIE)
- Profitability
  6. Earnings to sales (ES)
  7. Return on assets (ROA)
  8. Return on equity (ROE)
- Turnover
  9. Total assets turnover (TAT)
  10. Inventory turnover (IT)
  11. Accounts receivable turnover (ART)

The number of positive and negative differences of the individual observations from the mean is counted and the probability of the outcome is assessed under the null hypothesis. Since positive as well as negative skewness can be expected a two-sided test is appropriate (Dixon and Massey, 1957, p. 417).

(iii) A methodological problem

It should be noted that there is a flaw in the methodology presented here.[12] The correct procedure would be to postulate a null-hypothesis of non-normality (or non-symmetry) in order to detect normality or symmetry. But an operational formulation of such a null-hypothesis is difficult, as the number of alternative hypothetical distributions is large. So the null-hypothesis of normality (or symmetry) is used. Consequently, the probability of rejecting this hypothesis, when it is correct in reality, in minimized. Thus it will be rejected only in cases of very evident non-normality (or non-symmetry). Therefore the number of instances of normality (or symmetry) may be overstated.

Transformation

Transformation is an obvious way to improve the normality of a ratio distribution. However, a number of transformations are not always possible. It is impossible, for instance, to use logarithmic or square root transformations for ratios that can be negative. Frecka and Hopwood (1983) and apparently Deakin (1976) as well, circumvent this difficulty by adding the greatest negative score plus a small positive real number to all observations. There is, however, some arbitrariness in this procedure since the magnitude of the small positive real number, which in effect becomes the smallest observation, may influence greatly the resulting distribution. If it is sufficiently small it will produce an outlier.

Other transformations change the order of the observations, which in itself is not an objection, but some of these change the order in different directions for positive and negative values. They turn the original distribution inside-out as it were. An example is the 'inverse' transformation.

In this paper four transformations are performed: natural log(lnX), inverse (1/X), square root (SQR(X)) and cube root (CBR(X)). Only the last transformation is used for all eleven ratios. Ratios three to eight can be negative and so the logarithmic, inverse, and square root transformations were only performed for ratios 1, 2, 9, 10 and 11. Therefore in all 37 ratio/transformation combinations were analysed for each year.

Truncation: Removal of Outliers

Bougen and Drury (1980) remove observations greater than three s.d. from the mean to improve normality, providing that the loss of observations is reasonable. They do not state their criterion of reasonableness, but hint that a loss of 25 per cent is not acceptable. Since they only present results after truncation it is difficult to judge the success of this operation. Donnithorne (1981) sets, rather arbitrarily, minimum and maximum values for each ratio beyond which observations are removed. Without success however since normality is still rejected in all cases. Frecka and Hopwood (1983) remove observations from the transformed distributions (SQR(X)) until skewness or kurtosis, which ever happens first, is no longer different from the skewness or the kurtosis of the normal distribution at the one per cent significance level. In 1978 and 1979 the loss of observations for their overall sample ranged from nought per cent to ten per cent. They show that truncation dramatically improves the goodness-of-fit to the normal distribution (see Table 1, supra).

While it is clear that outliers resulting from data errors should be discarded, as should all ratio scores calculated from deficient annual accounts, any further truncation is debatable.

A general argument against the procedure is of course that it seems strange to test for normality only after the observations that presumably would belie normality have been removed. Two further arguments can be made against truncation specifically in the context of financial statement analysis. The first is that ratios are often interdependent and that to discard observations on one ratio should logically lead to elimination of seemingly normal observations calculated from the same financial statement on the interdependent ratios. For example, given a Debt to Equity ratio of, say, one and a certain level of current assets, even an extreme Current Ratio due to a very low level of current liabilities will coincide with a perfectly innocent looking Long Term Debt to Equity Ratio. However, if the outlying CR is suspect why not then the LTDE ratio? The second argument is that it is difficult to see how 'suspicious observations' can exist when the financial statements from which the observations are calculated are carefully drawn up.

In this paper therefore no outliers are removed after a procedure to control the quality of the data. This procedure is outlined in the next paragraph.

Outline of the Procedure to Control Data Quality

Although the data base, the magnetic tapes of the 'Balanscentrale', is potentially very valuable it cannot really be used until after each annual account in it has been carefully checked.[13] Of course, the amounts given must be accepted[14] but it is advisable to perform a series of logical tests. In Jegers and Buijink (1983) 156 tests are described and performed and the overall results given. Each of the ratios in this paper was calculated only after an appropriate subset of the 156 tests had been passed.

Observations with personnel costs of less than one million B.F. were also discarded, as were observations with total assets or total sales of less than five million B.F. For ratios one to four only the total assets size limit was retained. The overall consequences of this procedure are shown in Table 4 in which the initial number of observations on tape each year in the manufacturing industries is compared with the minimum and maximum number used depending on the ratio analysed, following the procedure outlined above,[15] and also after the tests on the required minimum number of observations per three- or two-digit industry and on the fiscal year closing date have been carried out. Of course, division by zero also eliminated some observations.

Table 4

Overall Effect of Data Quality Control

			1977	1978	1979	1980	1981
I			3250	4268	4490	4532	4505
F	2-digit industries	min.	1962	2178	2333	2432	2468
		max.	3134	3519	3757	3849	3839
	3-digit industries	min.	1786	1979	2137	2263	2307
		max.	2957	3379	3630	3707	3698

I = initial number of observations on tape in manufacturing industries
F = number of observations used

RESULTS

Introduction

Table 5 cross-classifies ratios and transformations for each of the five years. In the previous section headed Method, it was explained that the logarithmic, inverse, and square root transformations, were not used for ratios three to eight, hence the blank cells in the middle of each panel of Table 5. The first row (X) in each panel of that table gives the results for the distributions of the untransformed ratios. The next four rows show results for the transformations. The results shown are percentages: the percentage of manufacturing industries at the three-digit NACE level in which the normality of the ratio-distribution in question could not be rejected. For instance, in 1978, the hypothesis of normality of the distribution of the logarithmically transformed (ln X) Quick Ratio (QR) could not be rejected in 62 per cent of the three-digit manufacturing industries studied. The confidence level is 95 per cent. To facilitiate the interpretations of Table 5 a # indicates percentages of 50 or more and a ** indicates percentages of over 90. Table 6 presents similar results for two-digit industries. In Tables 7 and 8 results at both levels of aggregation for the symmetry hypothesis are presented. Symmetry here includes normality. Appendix A shows for one year, 1977, for each case the number of industries involved, the average number of observations per industry and the highest number of observations in any one industry.[16]

Table 5

Percentage of Three-Digit Manufacturing Industries for which the Hypothesis of Normality of the Ratio Distribution in Question could not be Rejected. (Significance level: five per cent)

year : 1977

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	18%	22%	10%	4%	13%	49%	63% #	25%	66% #	13%	29%
lnX : N	47%	65%							79% #	66% #	59% #
1/X : N	49%	32%							28%	43%	60% #
SQR(X) : N	36%	43%							85% #	38%	40%
CBR(X) : N	43%	54% #	29%	29%	23%	12%	16%	12%	85% #	47%	46%

year : 1978

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	23%	23%	10%	4%	8%	52% #	58% #	19%	70% #	18%	27%
lnX : N	47%	62% #							67% #	73% #	61% #
1/X : N	52% #	37%							25%	48%	65% #
SQR(X) : N	34%	38%							82% #	37%	41%
CBR(X) : N	37%	46%	27%	41%	24%	11%	17%	11%	90%**	46%	44%

year : 1979

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	20%	20%	9%	6%	6%	49%	54% #	23%	70% #	15%	32%
lnX : N	46%	63% #							68% #	58% #	60% #
1/X : N	56% #	33%							30%	55% #	51% #
SQR(X) : N	26%	34%							79% #	26%	50% #
CBR(X) : N	30%	48%	28%	39%	11%	10%	9%	6%	81% #	30%	53% #

year : 1980

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	16%	24%	5%	6%	10%	51% #	63% #	20%	72% #	15%	29%
lnX : N	46%	54% #							72% #	65% #	61% #
1/X : N	54% #	30%							36%	44%	60% #
SQR(X) : N	27%	35%							83% #	32%	44%
CBR(X) : N	29%	46%	27%	43%	16%	17%	13%	17%	83% #	40%	47%

year : 1981

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	19%	36%	13%	5%	12%	53% #	49%	25%	73% #	7%	27%
lnX : N	44%	71% #							73% #	56% #	62% #
1/X : N	50% #	29%							29%	41%	56% #
SQR(X) : N	29%	46%							88% #	29%	38%
CBR(X) : N	27%	58% #	33%	46%	10%	11%	9%	13%	88% #	34%	45%

Table 6

Percentage of Two-Digit Manufacturing Industries for which the Hypothesis of Normality of the Ratio Distribution in Question could not be Rejected. (Significance level: five per cent)

year : 1977

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	0%	0%	0%	0%	6%	17%	28%	12%	22%	0%	0%
lnX : N	22%	33%							44%	41%	6%
1/X : N	11%	6%							6%	6%	18%
SQR(X) : N	6%	22%							44%	12%	6%
CBR(X) : N	6%	22%	0%	11%	0%	17%	6%	0%	50% #	12%	6%

year : 1978

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	0%	0%	0%	0%	6%	17%	22%	6%	28%	6%	6%
lnX : N	6%	11%							44%	39%	28%
1/X : N	6%	6%							0%	11%	22%
SQR(X) : N	0%	0%							61% #	11%	17%
CBR(X) : N	6%	17%	0%	6%	6%	0%	6%	6%	61% #	11%	17%

year : 1979

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	0%	0%	0%	0%	0%	17%	28%	6%	39%	0%	11%
lnX : N	6%	17%							33%	28%	17%
1/X : N	11%	0%							11%	11%	17%
SQR(X) : N	0%	0%							44%	17%	17%
CBR(X) : N	0%	0%	6%	17%	6%	11%	6%	0%	56% #	17%	22%

year : 1980

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	0%	6%	0%	0%	0%	17%	33%	0%	28%	11%	6%
lnX : N	0%	22%							44%	22%	28%
1/X : N	22%	6%							11%	11%	11%
SQR(X) : N	0%	11%							50% #	11%	22%
CBR(X) : N	0%	17%	11%	11%	0%	0%	6%	0%	56% #	11%	22%

year : 1981

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : N	0%	0%	0%	0%	0%	28%	22%	0%	17%	0%	0%
lnX : N	6%	28%							39%	22%	28%
1/X : N	28%	11%							6%	6%	17%
SQR(X) : N	6%	17%							67% #	6%	0%
CBR(X) : N	6%	28%	0%	11%	11%	6%	0%	0%	72% #	6%	6%

Table 7

Percentage of Three-Digit Manufacturing Industries for which the Hypothesis of Symmetry of the Ratio Distribution in Question could not be Rejected. (Significance level: five per cent) (Symmetry includes normality)

year : 1977

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	46%	43%	42%	33%	33%	93%••	94%••	57% *	93%••	50% *	54% *
lnX : S	88% *	94%••							99%••	94%••	91%••
1/X : S	81% *	65% *							68% *	82% *	87% *
SQR(X) : S	65% *	71% *							100%••	74% *	66% *
CBR(X) : S	75% *	82% *	83% *	96%••	82% *	59% *	54% *	69% *	100%••	82% *	75% *

year : 1978

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	49%	47%	42%	35%	29%	95%••	94%••	65% *	96%••	43%	52% *
lnX : S	89% *	97%••							97%••	96%••	91%••
1/X : S	80% *	61% *							58% *	75% *	92%••
SQR(X) : S	57% *	68% *							100%••	70% *	64% *
CBR(X) : S	67% *	75% *	89% *	95%••	71% *	50% *	54% *	62% *	100%••	76% *	73% *

year : 1979

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	48%	51% *	45%	37%	23%	90%••	96%••	56% *	95%••	44%	57% *
lnX : S	88% *	96%••							97%••	96%••	94%••
1/X : S	78% *	61% *							63% *	75% *	89% *
SQR(X) : S	67% *	73% *							99%••	63% *	75% *
CBR(X) : S	70% *	85% *	90%••	96%••	69% *	50% *	45%	65% *	99%••	71% *	85%••

year : 1980

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	44%	46%	38%	39%	37%	94%••	97%••	58% *	89% *	44%	54% *
lnX : S	85% *	95%••							99%••	94%••	93%••
1/X : S	80% *	61% *							65% *	76% *	89% *
SQR(X) : S	63% *	73% *							97%••	67% *	68% *
CBR(X) : S	68% *	78% *	91%••	98%••	74% *	61% *	49%	61% *	100%••	76% *	78% *

year : 1981

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	49%	50% *	45%	38%	29%	94%••	93%••	54% *	95%••	36%	54% *
lnX : S	93%••	100%••							97%••	92%••	94%••
1/X : S	83% *	70% *							67% *	79% *	87% *
SQR(X) : S	64% *	81% *							99%••	58% *	70% *
CBR(X) : S	74% *	94%••	89% *	96%••	71% *	49%	43%	72% *	99%••	67% *	83% *

Table 8

Percentage of Two-Digit Manufacturing Industries for which the Hypothesis of Symmetry of the Ratio Distribution in Question could not be Rejected. (Significance level: five per cent) (Symmetry includes normality)

year : 1977

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	17%	6%	6%	0%	6%	78% #	83% #	29%	50% #	6%	12%
lnX : S	56% #	89% #							94% **	71% #	59% #
1/X : S	61% #	17%							17%	24%	53% #
SQR(X) : S	22%	28%							100% **	29%	12%
CBR(X) : S	22%	28%	72% #	78% #	76% #	33%	22%	35%	100% **	35%	12%

year : 1978

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	6%	6%	11%	11%	6%	78% #	89% #	22%	61% #	11%	17%
lnX : S	50% #	89% #							89% #	72% #	61% #
1/X : S	33%	11%							17%	39%	56% #
SQR(X) : S	6%	22%							94% **	22%	22%
CBR(X) : S	6%	22%	72% #	78% #	50% #	22%	28%	33%	100% **	39%	28%

year : 1979

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	6%	6%	6%	22%	6%	89% #	83% #	50% #	61% #	17%	28%
lnX : S	33%	94% **							72% #	67% #	67% #
1/X : S	39%	11%							17%	33%	56% #
SQR(X) : S	11%	28%							89% #	22%	33%
CBR(X) : S	17%	39%	72% #	89% #	61% #	17%	17%	28%	89% #	28%	39%

year : 1980

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	6%	11%	11%	11%	11%	89% #	94% #	28%	61% #	11%	22%
lnX : S	33%	89% #							83% #	67% #	61% #
1/X : S	50% #	6%							22%	28%	44%
SQR(X) : S	11%	28%							94% **	11%	28%
CBR(X) : S	17%	39%	83% #	78% #	39%	17%	11%	22%	100% **	17%	39%

year : 1981

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X : S	6%	11%	6%	11%	11%	78% #	83% #	22%	50% #	6%	6%
lnX : S	28%	94% **							89% #	61% #	56% #
1/X : S	50% #	28%							11%	17%	50% #
SQR(X) : S	6%	44%							94% **	11%	17%
CBR(X) : S	17%	50% #	94% **	94% **	44%	22%	17%	22%	94% **	28%	28%

Effects of Aggregation

The cells in the panels of Table 5 can be compared with the corresponding cells of Table 6. This comparison reveals that in almost all cases, 182 out of the possible 185, the three-digit industry level results show a higher proportion of industries for which the normality hypothesis cannot be rejected before or after transformation. A similar comparison of Tables 7 and 8 leads to the same general conclusion regarding the hypothesis of symmetry (184 out of the possible 185). The level of aggregation thus has an unmistakable effect on the rejection of the normality and symmetry hypotheses.

Other Results

Tables 5 and 7 show that the ratios with a range of $(0, +\infty)$, viz. CR, QR, DE, LTDE, TAT, IT and ART, have in general positively skewed distributions of raw scores, because the transformations that reduce this type of skewness appear to work well. For the other four ratios TIE, ES, ROA and ROE with a range of $(-\infty, +\infty)$ the skewness reducing transformations do not seem to work well. All this is in agreement with earlier findings.

Apart from the results for the individual ratios there is a more general conclusion that may be drawn from Tables 5 and 7 with more direct consequences with regard to the choice of statistical tools. Table 5 shows that for the CR, QR, ES, ROA, TAT, IT and ART ratios, there exists for each year, with three slight exceptions, at least one transformation that achieves normality in a majority of the industries. Table 7 shows that for all ratios, except the ROE ratio, there exists at least one transformation that achieves symmetry in 80 per cent of the industries or more.

In the section below headed Additional Remarks, the results presented so far are scrutinized in more detail.

Persistence of Distributional Characteristics Over Time

The persistence of distributional characteristics over time may be studied in the following manner: given a no-persistence hypothesis, symmetry (including normality), left-asymmetry and right-asymmetry are distributed independently over the five years. The expected number of industries, as a fraction of the total number, which will, given this hypothesis, be in each year in the same distributional class is, for a given ratio and transformation:

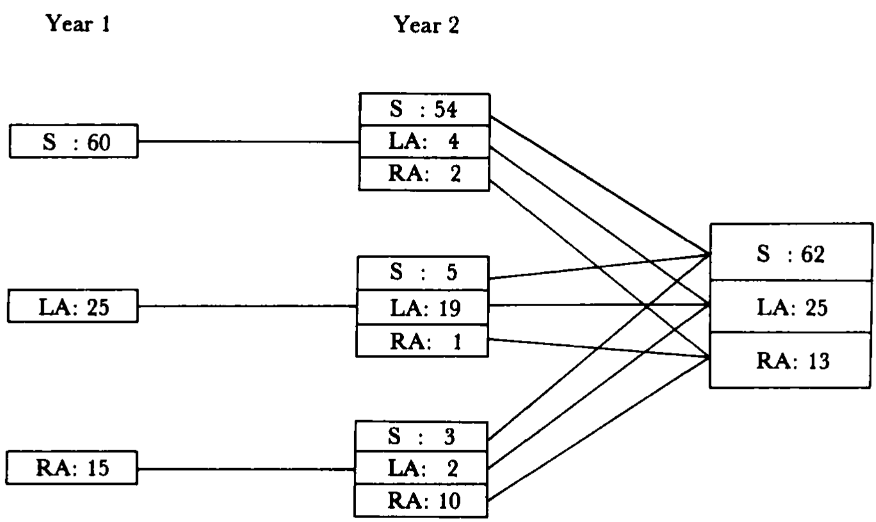
$$\prod_{i=1}^{5} p_{Si} + \prod_{i=1}^{5} p_{LAi} + \prod_{i=1}^{5} p_{RAi}$$

where p_{Si} is the fraction of industries in which the given ratio/transformation was symmetrically distributed inyear i + 1976, and p_{LAi} en p_{RAi} were similarly calculated for the asymmetrical cases.

The binomial distribution is used to test whether the observed fraction of industries[17] in which the given ratio/transformation is persistently, that is to say in all five years, identically distributed, is more than 1.65 standard deviations away from the expected fraction with the null hypothesis of independence. It turns out that at this one sided 95 per cent confidence level independence must be rejected, for 29 of the 37 possible ratio/transformation combinations. This means that ratio distributions often have the same form in consecutive years.

An example may make the rationale of this test clear. In Figure 1 a fictitious group of 100 industries is split up into the three distributional classes for two years.

Figure 1



In the case of independence one should expect 62 per cent of the 60 industries symmetrically distributed in the first year, to be distributed symmetrically in the second year. The same argument applies to the LA and RA cases. One should therefore expect:

$$100 \times [(0.60)(0.62) + (0.25)(0.25) + (0.15)(0.13)] = 45\%$$

of the industries to remain in the same distributional class. This percentage is to be compared, with a binomial test, with the 83 per cent (54 + 19 + 10) of the industries that actually remained in the same distributional class.

ADDITIONAL REMARKS

The Case of Several 'Successful' Transformations

It is clear from Table 5[18] that at the three-digit industry level there are quite a few instances in which several transformations, or the raw scores, and simultaneously one or more transformations, lead to normality. It may be thought that the identity of the industries in which normality was achieved is different for different transformations. However, one glance at Table 5 suffices to show that there must be considerable overlap between successful transformations. This is most clearly the case for the TAT ratio. To quantify the extent of overlap Table 9 shows for each ratio the percentage (0) of industries in 1981 for which there existed more than one 'successful' transformation to normality, where transformation must be understood to include the raw score case.

Table 9

Extent of Overlap Between Transformations

Year: 1981
Observations: Three-Digit Manufacturing Industries

	CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
0	41%	64%	11%	5%	4%	11%	9%	9%	90%	42%	58%
g(0)	22.7	28.3	13.9	13.0	12.7	15.8	14.0	14.5	35.4	21.5	23.5
– 0	59%	36%	89%	95%	96%	89%	91%	91%	10%	58%	42%
g(– 0)	62.8	77.8	50.4	48.0	34.4	41.5	39.8	37.3	66.9	49.3	59.5
n.	80	80	80	80	69	70	69	69	73	73	71

Table 9 also gives for each ratio the percentage (– 0) of industries for which there existed at most one successful transformation. Also given is the average number of observations per industry in both cases (g(0) and g(– 0)), as well as the total number of industries involved in each case (n).

The overlap percentages are not very high for the DE, LTDE, TIE, ES, ROA, and ROE ratios but of course for these only the raw scores and the cube root transformation were used.

The percentage is especially high for the TAT ratio, as could be expected from Table 5. But the overlap percentage is also disturbingly high for the CR, QR, IT and ART ratios. One possible explanation for this result is that the average number of observations in industries in which overlap occurs is always much lower than the corresponding average number in industries where no overlap occurs. This points to a sample size effect which affects the normality test and which is independent of the type of transformation. This is taken up in the next paragraph. However, part of the explanation may also lie in the numbers and transformations involved. Take the TAT ratio for instance, for the industry 'Drawing, cold rolling and cold folding of steel' in 1981. In that year there were 22 acceptable observations in this industry. Table 10 gives the TAT ratios of these 22 firms in raw and transformed form, leaving out the inverse transformation.[19]

Table 10

Raw and Transformed Scores of the TAT Ratio in N.A.C.E. Industry 223, in 1981.

	X	ln X	SQR(X)	CBR(X)
	0.164	- 1.807	0.405	0.548
	0.197	- 1.626	0.443	0.582
	0.430	- 0.843	0.656	0.755
	0.628	- 0.466	0.792	0.856
	0.958	- 0.043	0.979	0.986
	1.047	0.046	1.023	1.016
	1.148	0.138	1.071	1.047
	1.275	0.243	1.129	1.084
	1.351	0.301	1.163	1.106
	1.372	0.316	1.171	1.111
	1.395	0.333	1.181	1.117
	1.462	0.380	1.209	1.135
	1.524	0.421	1.235	1.151
	1.790	0.582	1.338	1.214
	1.792	0.583	1.339	1.215
	1.824	0.601	1.351	1.222
	1.935	0.660	1.391	1.246
	2.065	0.725	1.437	1.273
	2.139	0.760	1.463	1.288
	2.426	0.886	1.558	1.344
	2.576	0.946	1.605	1.371
	2.851	1.408	1.688	1.418
n	22	22	22	22
mean	1.470	0.190	1.165	1.095
s.d.	0.728	0.759	0.345	0.233
c.v.D	0.190	0.190	0.190	0.190
D	0.079(*)	0.210 sym(*)	0.141(*)	0.164(*)

s.d. = standard deviation
c.v.D = critical value Lilliefors K-S test statistic
D = actual D ((*) normality not rejected at five per cent)
sym(*) = *symmetry not rejected at five per cent*

The table shows that in this particular case the ratio scores themselves explain the overlap. The raw scores of the TAT ratio lie around one, and themselves already allow the normality hypothesis to be accepted, with the consequence that the square root and cube root transformations merely pull the sample distribution inward towards one.

How general the validity of this type of explanation is, is not explored further in this paper. Of course, the concern in this section with the occurence of overlap vanishes if data are analysed with clear theoretical expectations regarding the form of the ratio distributions. On the basis of these one could presumably establish the order in which the transformations, including the raw scores case, should be looked at.

Effect of Sample Size on the Rejection of the Normality Hypothesis

As Deakin (1976, p.95) suggests, the outcome of the normality test might be influenced by the number of observations in an industry. In order to investigate this proposition, the following procedure was devised.

For each case (a given year, variable and transformation) a contingency-table was computed. An example, the untransformed Current Ratio in 1977 at the three-digit industry level, is given in Table 11.

Table 11

Contingency Table: The Relation Between Sample Size and Rejection of the Normality Hypothesis. (The untransformed CR in 1977, three-digit level)

	Industries with less than 30 observations	Industries with 30 observations or more	
normality rejected	25	34	59
normality accepted	12	1	13
	37	35	72

The χ^2 for this contingency table is 8.73 which is significant at the five per cent level. The effect is 'positive', by which is meant that in larger industries normality is significantly more often rejected than in smaller industries.

When in one of the cells the expected number of observations fell below five, the corresponding χ^2 was not considered.

In Table 12 the number of cases, per year, is given in which the independence of industry size and the rejection of the normality hypothesis could not be accepted.

The conclusion from this table is clear: in most of the cases a positive relation exists between sample size and the rejection of normality. Table 13 gives

Table 12

Relation Between Sample Size and Rejection of the Normality Hypothesis

	1977	1978	1979	1980	1981
cases considered	27	29	29	30	28
independence rejected at five per cent	13	22	16	22	24

Table 13

Relation Between Sample Size and Rejection of the Symmetry Hypothesis

	1977	1978	1979	1980	1981
cases considered	22	24	23	24	22
independence rejected at five per cent	14	16	17	20	16

similar results for the symmetry hypothesis. Here again in most cases a positive relation exists between sample size and the rejection of symmetry.

To check how all this affects the results in Tables 5–8, the analysis was performed once again for one year (1981) using only industries with 30 observations or more. The results are given in Tables 14 and 15.

Although normality and symmetry are more frequently rejected, the results outlined in the discussion in the sub-sections headed Effects of Aggregation, and Other Results above re-emerge.

CONCLUSION

The previous paragraphs show that there is persistence in the form of ratio distributions, if necessary suitably transformed, from year to year. They also show that the eleven raw or transformed ratios studied were invariably more often normally or symmetrically distributed at a three-digit level of manufacturing industries than at the more broadly defined two-digit level.

This finding corroborates the evidence of the importance of industry homogeneity for the form of ratio distributions presented in Table 1. That is,

Table 14

Percentage of Three- and Two-Digit Manufacturing Industries for which the Hypothesis of Normality of the Ratio Distribution in Question could not be Rejected.
(Significance level: five per cent, minimum number of observations per industry: 30)

year : 1981
observations : Three-digit industries in Belgian manufacturing (= N.A.C.E. one-digit industries 2,3, and 4)

		CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X	: N	3%	8%	0%	0%	0%	42%	24%	0%	56% #	0%	6%
	n.	40	40	40	40	28	33	29	28	34	32	33
	m	74	74	74	74	58	62	64	61	63	63	63
lnX	: N	20%	63% #							71% #	44%	42%
	n.	40	40							34	32	33
	m	74	74							63	63	63
1/X	: N	27%	8%							12%	19%	30%
	n.	40	40							34	32	33
	m	74	74							63	63	63
SQR(X)	: N	10%	20%							82% #	9%	12%
	n.	40	40							34	32	33
	m	74	74							63	63	63
CBR(X)	: N	8%	33%	8%	18%	0%	3%	0%	4%	79% #	16%	24%
	n.	40	40	40	40	28	33	29	28	34	32	33
	m	74	74	74	74	58	62	64	61	63	63	63

year : 1981
observations : Two-digit industries in Belgian manufacturing (= N.A.C.E. one-digit industries 2,3 and 4)

		CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X	: N	0%	0%	0%	0%	0%	19%	19%	0%	13%	0%	0%
	n.	16	16	16	16	15	16	16	15	16	15	16
	m	238	238	238	238	161	178	172	171	183	189	181
lnX	: N	0%	19%							38%	7%	19%
	n.	16	16							16	15	16
	m	238	238							183	189	181
1/X	: N	19%	0%							0%	7%	6%
	n.	16	16							16	15	16
	m	238	238							183	189	181
SQR(X)	: N	0%	13%							63% #	0%	0%
	n.	16	16							16	15	16
	m	238	238							183	189	181
CBR(X)	: N	0%	19%	0%	6%	0%	0%	0%	0%	69% #	0%	0%
	n.	16	16	16	16	15	16	16	15	16	15	16
	m	238	238	238	238	161	178	172	171	183	189	181

N = normal
n. = number of three- or two-digit industries analysed
m = average number of observations per industry

Table 15

Percentage of Three- and Two-Digit Manufacturing Industries for which the Hypothesis of Symmetry of the Ratio Distribution in Question could not be Rejected.
(Significance level: five per cent, minimum number of observations per industry: 30, symmetry includes normality)

year : 1981
observations : Three-digit industries in Belgian manufacturing (= N.A.C.E. one-digit industries 2,3, and 4)

		CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X	:S	13%	18%	20%	10%	7%	97% #	90% #	18%	88% #	9%	24%
	n.	40	40	40	40	28	33	29	28	34	32	33
	m	74	74	74	74	58	62	64	61	63	63	63
lnX	:S	88% #	100%**							94%**	88% #	88% #
	n.	40	40							34	32	33
	m	74	74							63	63	63
1/X	:S	73% #	50% #							53% #	63% #	79% #
	n.	40	40							34	32	33
	m	74	74							63	63	63
SQR(X)	:S	35%	68% #							97%**	28%	55% #
	n.	40	40							34	32	33
	m	74	74							63	63	63
CBR(X)	:S	55% #	90%**	85% #	95%**	54% #	24%	10%	57% #	97%**	41%	73% #
	n.	40	40	40	40	28	33	29	28	34	32	33
	m	74	74	74	74	58	62	64	61	63	63	63

year : 1981
observations : Two-digit industries in Belgian manufacturing (= N.A.C.E. one-digit industries 2,3 and 4)

		CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X	: N	0%	0%	6%	13%	0%	75% #	81% #	7%	44%	0%	0%
	n.	16	16	16	16	15	16	16	15	16	15	16
	m	238	238	238	238	161	178	172	171	183	189	181
lnX	: S	19%	94%**							88% #	53% #	50% #
	n.	16	16							16	15	16
	m	238	238							183	189	181
1/X	: S	44%	19%							6%	7%	44%
	n.	16	16							16	15	16
	m	238	238							183	189	181
SQR(X)	: S	0%	38%							94%**	0%	6%
	n.	16	16							16	15	16
	m	238	238							183	189	181
CBR(X)	: S	13%	44%	94%**	94%**	33%	13%	6%	7%	94%**	13%	19%
	n.	16	16	16	16	15	16	16	15	16	15	16
	m	238	238	238	238	161	178	172	171	183	189	181

S = symmetry
n. = number of three- or two-digit industries analysed
m = average number of observations per industry

researchers who use financial ratio data and apply parametric statistical techniques should do so only in settings in whch they have data on firms from industries at a low level of aggregation. This is certainly so if the techniques are robust in the sense that the symmetry of the underlying ratio distributions is already sufficient to allow a correct probabilistic interpretation. If data are only available for broad industries, it is advisable to test for the normality or symmetry of the underlying distribution, possibly after a suitable transformation. The results in this paper suggest that in such cases non parametric statistical techniques will be appropriate more often than not.

NOTES

1 It should be noted that firm sizes, a frequent ratio component, invariably are found to have very skew distributions, see for instance R. Clarke (1978).

2 See Foster (1978) pp. 58–62 for a more detailed discussion of this point.

3 For the distribution of the ratio of two normally distributed variables, see Marsaglia (1965).

4 Previous work, without quantitative detail, in this area includes contributions by Horrigan (1965) and O'Connor (1973). Another approach based on maximum likelihood estimations of transformation and distribution parameters can be found in McLeay (1984).

5 This result is also hinted at by Bougen and Drury (1980), p. 44, and Deakin (1976), p. 95, but they do not present detailed evidence.

6 Roughly: N.V. = joint stock company, P.V.B.A. = association of persons enjoying limited liability, C.V. = limited partnership and B.V. = professional association taking the form of a business company.

7 For a more thorough discussion of the criteria that lead to the annual accounts of a Belgian company being recorded on the tapes and a discussion of the recent reforms of Belgian accounting legislation as a result of the EEC's fourth directive, see Lefebvre (1984).

8 In 1977, only the annual accounts of firms with an accounting fiscal year ending on December 31 were filed.

9 Precise definitions with references to standard Belgian annual accounts can be obtained from the authors.

10 N.A.C.E. stands for General Industrial Classification of Economic Activities of the EEC. This classification distinguishes ten main industries each designated with a single digit, 0–9, and more detailed industries at a two-, three- and four-digit level.
The two- and three-digit level industries studied are the classes and groups in the one-digit NACE-industries two, three and four.
See: Statistical Office of the E.E.C. (1970).

11 A corrected table was in fact used, see Conover (1971) p. 398.

12 As well as in all previous work on this subject.

13 The Compustat tape used by Deakin (1978) and Frecka and Hopwood (1977) is apparently not error free either. See San Miguel (1977). See also Rosenberg and Houghlet (1974) and Bennin (1980) for apparent errors in the stock exchange data on the Compustat tape.

14 There is no 'competing' data base in Belgium, therefore no cross-checking is possible.

15 It should be remembered that concise annual accounts were not used in the analysis of ratios 5–11. This obviously also entails loss of observations.

16 Appendix A gives in more detail the results for 1977 also shown at the top of Tables 5 and 6. Similar more detailed results for each year in Tables 5–8 can be obtained from the authors.

17 Only those industries that were available in all five years were taken into consideration.

18 As well as from Table 6. However, the focus of this section is on the normality hypothesis.

19 Because the percentage of industries in which that transformation worked well is comparatively small.

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APPENDIX A
Detailed Results

N = percentage of industries in which the normality of the ratio distribution in question could not be rejected

– N = complement of N

S = percentage of industries in which the ratio distribution in question could *not* be termed normal, but in which the symmetry hypothesis could not be rejected

Year : 1977
Observations : Three-Digit Industries in Belgian Manufacturing (= N.A.C.E. one-digit industries 2,3, and 4)

		CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X	: N	18%	22%	10%	4%	13%	49%	63%	25%	66%	13%	29%
	– N	82%	78%	90%	96%	87%	51%	37%	75%	34%	87%	71%
	S	34%	27%	35%	30%	23%	86%	84%	42%	78%	42%	35%
	– S	66%	73%	65%	70%	77%	14%	16%	58%	22%	58%	65%
	n.	72	72	72	72	61	68	68	67	68	68	68
	m	41	41	41	41	29	32	31	30	33	32	33
	H	170	170	170	170	92	112	107	100	113	112	112
lnX	: N	47%	65%							79%	66%	59%
	– N	53%	35%							21%	34%	41%
	S	76%	84%							93%	83%	79%
	– S	24%	16%							7%	17%	21%
	n.	72	72							68	68	68
	m	41	41							33	32	33
	H	170	170							113	112	112
1/X	: N	49%	32%							28%	43%	60%
	– N	51%	68%							72%	57%	40%
	S	62%	49%							55%	69%	67%
	– S	38%	51%							45%	31%	33%
	n.	72	72							68	68	68
	m	41	41							33	32	33
	H	170	170							113	112	112
SQR(X)	: N	36%	43%							85%	38%	40%
	– N	64%	57%							15%	62%	60%
	S	46%	49%							100%	57%	44%
	– S	54%	51%							0%	43%	56%
	n.	72	72							68	68	68
	m	41	41							33	32	33
	H	170	170							113	112	112
CBR(X)	: N	43%	54%	29%	29%	23%	12%	16%	12%	85%	47%	46%
	– N	57%	46%	71%	71%	77%	88%	84%	88%	15%	53%	54%
	S	56%	61%	76%	94%	77%	53%	46%	64%	100%	67%	54%
	– S	44%	39%	24%	6%	23%	47%	54%	36%	0%	33%	46%
	n.	72	72	72	72	61	68	68	67	68	68	68
	m	41	41	41	41	29	32	31	30	33	32	33
	H	170	170	170	170	92	112	107	100	113	112	112

– S = complement of S

n = number of industries studied

m = average number of observations in the number of industries studied

H = highest number of observations in the number of industries studied

level of significance: 0.05 throughout.

Year : 1977

Observations : Two-Digit Industries in Belgian Manufacturing (= N.A.C.E. one-digit industries 2,3, and 4)

		CR	QR	DE	LTDE	TIE	ES	ROA	ROE	TAT	IT	ART
X	: N	0%	0%	0%	0%	6%	17%	28%	12%	22%	0%	0%
	– N	100%	100%	100%	100%	94%	83%	72%	88%	78%	100%	100%
	S	17%	6%	6%	0%	0%	73%	77%	20%	36%	6%	12%
	– S	83%	94%	94%	100%	100%	27%	23%	80%	64%	94%	88%
	n.	18	18	18	18	17	18	18	17	18	17	17
	m	174	174	174	174	115	131	126	126	134	138	139
	H	453	453	453	453	313	371	350	334	382	372	374
lnX	: N	22%	33%							44%	41%	6%
	– N	78%	67%							56%	59%	94%
	S	43%	83%							90%	50%	56%
	– S	57%	17%							10%	50%	44%
	n.	18	18							18	17	17
	m	174	174							134	138	139
	H	453	453							382	372	374
1/X	: N	11%	6%							6%	6%	18%
	– N	89%	94%							94%	94%	82%
	S	56%	12%							12%	19%	43%
	– S	44%	88%							88%	81%	57%
	n.	18	18							18	17	17
	m	174	174							134	138	139
	H	453	453							382	372	374
SQR(X)	: N	6%	22%							44%	12%	6%
	– N	94%	78%							56%	88%	94%
	S	18%	7%							100%	20%	6%
	– S	82%	93%							0%	80%	94%
	n.	18	18							18	17	17
	m	174	174							134	138	139
	H	453	453							382	372	374
CBR(X)	: N	6%	22%	0%	11%	0%	17%	6%	0%	50%	12%	6%
	– N	94%	78%	100%	89%	100%	83%	94%	100%	50%	88%	94%
	S	18%	7%	72%	75%	76%	20%	18%	35%	100%	27%	6%
	– S	82%	93%	28%	25%	24%	80%	82%	65%	0%	73%	94%
	n.	18	18	18	18	17	18	18	17	18	17	17
	m	174	174	174	174	115	131	126	126	134	138	139
	H	453	453	453	453	313	371	350	334	382	372	374